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4. BIOLOGICAL INFORMATION FOR LISTED SPECIES

The Willamette Project has the potential to affect a number of species that are either listed or are candidates for listing under the ESA. This chapter identifies the biological requirements and characteristics of each species, ESU, or DPS identified in Chapter 1 as being of concern. General distributions, population trends, life history needs, and recovery efforts are described for each species. The amount of information available varies with species; the best available, most relevant information is summarized here.

4.1 FISH

There are ten fish species or stocks that may be affected by the Willamette Project that are either listed, are proposed for listing, or are candidates for listing under the ESA (Table 1-1). The information presented in this chapter pertains to known features of each species life history traits or requirements that are specific to the Willamette and lower Columbia River basins. Additional, detailed descriptions of general life histories, habitat requirements, and other needs can be found for the listed fish species in Groot and Margolis (1991), Meehan (1991), Emmett et al. (1991), Busby et al. (1996), Johnson et al. (1997), Myers et al. (1998), USFWS (1998), and Johnson et al. (1999). Life stage periodicities are depicted for species that are most likely to be influenced by Willamette Project activities, for specific subbasins and the system as a whole in Figures 4-1 through 4-4. Comparable information could not be developed comprehensively for the Coast Fork Willamette and Long Tom River subbasins, where listed species occur infrequently or not at all.

4.1.1 Upper Willamette River Spring Chinook Salmon ESU

There are two chinook salmon ESUs that may be affected by the Willamette Project. The Upper Willamette River ESU is more directly affected than the Lower Columbia River ESU. Most information provided in this BA is therefore for the former, although much of the general life history information is similar.

Designated critical habitat for upper Willamette spring chinook salmon presently extends upstream to Big Cliff, Green Peter, Blue River, Cottage Grove, Dorena, and Fern Ridge dams, and upstream of Foster, Cougar, and Dexter dams according to whether trap and haul operations move listed fish to habitat upstream (65 FR 7764).

Species	Freshwater Life Phase	Jan 1-15	16-31	Feb 1-15	16-28	Mar 1-15	16-31	Apr 1-15	16-30	May 1-15	16-31	Jun 1-15	16-30	Jul 1-15	16-31	Aug 1-15	16-31	Sep 1-15	16-30	Oct 1-15	16-31	Nov 1-15	16-30	Dec 1-15	16-31
Spring Chinook	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Smolt Outmigration [1]																								
Winter Steelhead	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Smolt Outmigration																								
Bull Trout	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing/Adults																								
Coastal Cutthroat	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Outmigration																								
Coho	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Smolt Outmigration																								
Oregon Chub	Spawning																								
	Incubation								Chub incubation is for approximately one week after spawning																
	Juvenile Rearing/Adults																								

[1] Includes fry.

Figure 4-1. General life stage periodicity chart for ESA listed fish species in the Willamette River basin, Oregon. Darker shade indicates heavier activity. Compiled from Nicholas (1978); USACE (1982); ODFW (1990a, b); Foster (1992); ODFW (1992); Cramer and Cramer (1994); Willis et al. (1995); Weitkamp et al. (1995); Busby et al. (1996); Buchanan et al. (1997); Myers et al. (1998); Unthank (1998); Taylor and Reasoner (1998); Scheerer (1999); Johnson et al. (1999); and Figures 6-2 through 6-4.

Species	Freshwater Life Phase	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Spring Chinook	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Smolt Outmigration																								
Winter Steelhead	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Smolt Outmigration																								
Bull Trout [1]	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing/Adults																								
Oregon Chub	Spawning																								
	Incubation								Chub incubation is for approximately one week after spawning																
	Juvenile Rearing/Adults																								

[1] May be reintroduced.

Figure 4-2.   Life stage periodicity chart for ESA listed fish species in the Santiam River basin, Oregon. Darker shade indicates heavier activity. Compiled from OSGC (1963); ODFW (1990c); Buchanan et al. (1997); Myers et al. (1998); Unthank (1998); Taylor and Reasoner (1998); and Scheerer (1999).

Species	Freshwater Life Phase	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
		1-15	16-31	1-15	16-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Spring Chinook	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Smolt Outmigration [1]																								
Bull Trout	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing/Adults																								
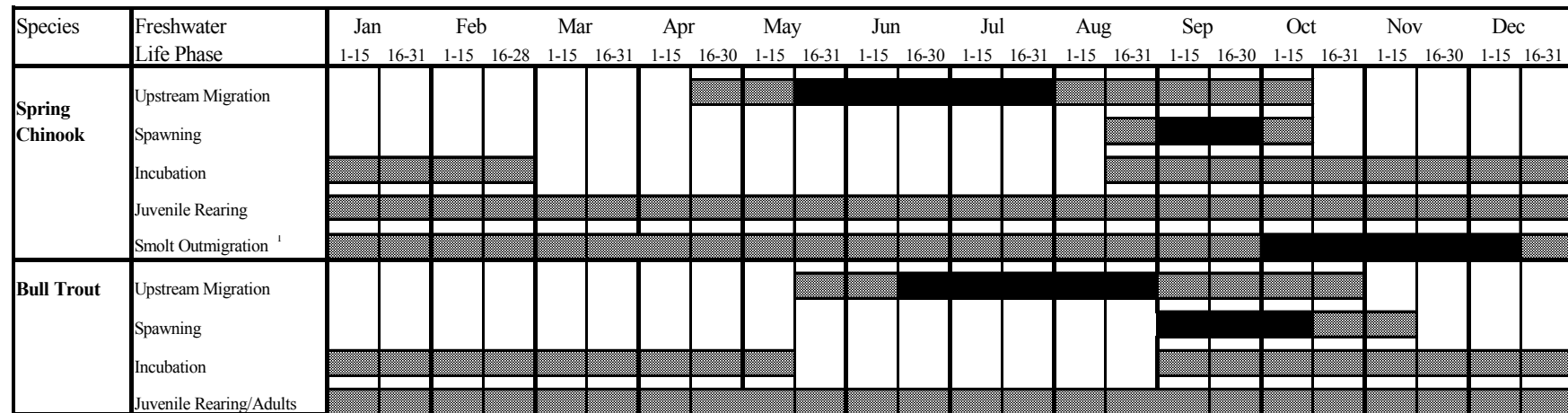
[1] Fry outmigration heavy between January and April (Willis et al. 1995).

Figure 4-3.   Life stage periodicity chart for ESA listed species in the McKenzie River basin, Oregon. Darker shade indicates heavier activity. Information is not available for winter steelhead. Compiled from ODFW (1990e); Humolka and Downey (1995); Willis et al. (1995); Buchanan et al. (1997); Unthank (1998); and Taylor and Reasoner (1998).

Species	Freshwater Life Phase	Jan 1-15	16-31	Feb 1-15	16-28	Mar 1-15	16-31	Apr 1-15	16-30	May 1-15	16-31	Jun 1-15	16-30	Jul 1-15	16-31	Aug 1-15	16-31	Sep 1-15	16-30	Oct 1-15	16-31	Nov 1-15	16-30	Dec 1-15	16-31
Spring Chinook	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Smolt Outmigration																								
Winter Steelhead[1]	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing																								
	Smolt Outmigration																								
Bull Trout[2]	Upstream Migration																								
	Spawning																								
	Incubation																								
	Juvenile Rearing/Adults																								
Oregon Chub	Spawning																								
	Incubation									Chub incubation is for approximately one week after spawning															
	Juvenile Rearing/Adults																								

[1] Introduced and not a part of the upper Willamette River Steelhead ESU.

[2] Re-introduction program initiated above Hill Creek Reservoir.

Figure 4-4.   Life stage periodicity chart for ESA listed fish species in the Middle Fork Willamette River basin, Oregon. Darker shade indicates heavier activity. Compiled from ODFW (1990f); Buchanan et al. (1997); Unthank (1998); Taylor and Reasoner (1998); and Scheerer (1999).

4.1.1.1 Subpopulations and Distributions

All naturally spawned populations of spring ("spring-run") chinook salmon residing above Willamette Falls, but below impassable natural barriers (e.g., long-standing, natural waterfalls) are considered to be members of this ESU. Additionally, NMFS concluded that the naturally-spawned population of spring chinook salmon in the Clackamas River (below Willamette Falls), derives from the Willamette ESU. NMFS also included five hatchery stocks from the Middle Fork Willamette (Oakridge), McKenzie, South Santiam, North Santiam, and Clackamas systems as members of the Upper Willamette River Chinook Salmon ESU. However, these stocks were specifically excluded from the listing and were not considered necessary for recovery of the ESU (64 FR 14308). Allozyme analyses indicate that wild spring chinook salmon from the upper Willamette River basin are similar genetically to hatchery fish from the Dexter, McKenzie, Marion Forks, and Clackamas hatcheries (Lindsay et al. 1999).

Spring chinook salmon above Willamette Falls are different from all other Columbia basin chinook according to both genetic and life history data (Schreck et al. 1986; Utter et al. 1989; Shaklee 1991; Waples et al. 1991; Myers et al. 1998). For example, Willamette spring chinook salmon exhibit an earlier time of entry into the Columbia River and estuary than inland spring chinook (Myers et al. 1998).

Significant natural spawning occurs in three subbasins: the McKenzie River, the North Santiam River, and the Clackamas River. Smaller amounts of natural production occur in other Willamette River subbasins. There are limited data available, however, regarding the genetic diversity of spring chinook spawning groups among the different subbasins. Schreck et al. (1986) evaluated characteristics of Columbia River basin spring chinook stocks, including body shape, meristic measures, biochemistry, and life history, and determined that fish from Willamette River subbasins were most like each other and that naturally produced spring chinook did not group separately from hatchery spring chinook in the Willamette River basin. Willamette River basin spring chinook salmon may thus be distinguished from other lower Columbia River stocks, but not from each other. Willis et al. (1995) determined that there is little to no genetic difference in spring chinook populations among the Willamette River subbasins, or between naturally producing and hatchery fish on the basis of genetic data and inherited life-history traits.

Available information indicates that the Upper Willamette River Chinook Salmon ESU may be divided into five major subpopulations:

Molalla and Pudding Subpopulation: Spring chinook are native to the Molalla River subbasin. The original run is believed to have declined to the point where it could no longer sustain a viable population because of extensive logging, agriculture, and ocean harvest during the 1960s (Cramer et al. 1996). Hatchery releases of spring chinook have been made in the subbasin starting in 1981 in an attempt to restore the run. There have been no recent observations of spring chinook in the Pudding River subbasin (ODFW 1999a).

Santiam and Calapooia Subpopulation: Spring chinook salmon are the only salmon species native to the Santiam and Calapooia River subbasins (ODFW 1990c; winter steelhead are also native). Spawning surveys conducted in the North Santiam during 1946 and 1947 indicated that an estimated 71 percent of spring chinook production there occurred above the Detroit Dam (Mattson 1948). Spawning habitat upstream was lost after the dam was constructed because fish passage facilities were not incorporated. Historically, 85 percent of the production of spring chinook in the South Santiam system occurred above Foster Dam (Mattson 1948); adults are currently released above Foster Dam by ODFW. By the 1970s natural production in the Calapooia was thought to be minimal to non-existent (ODFW 1990c).

Middle Fork Willamette Subpopulation: Spring chinook are native to the Middle Fork Willamette River subbasin and historically may have comprised the largest run of spring chinook of all the subbasins above Willamette Falls (ODFW 1992). Dexter and Fall Creek dams blocked approximately 80 percent of habitat historically accessible to spring chinook salmon in the subbasin (ODFW 1990f).

McKenzie Subpopulation: Spring chinook salmon are native to the McKenzie River subbasin. Prior to the construction of dams on the tributaries of the Willamette River, the McKenzie produced an estimated 40 percent of the run of spring chinook above Willamette Falls (Mattson 1948). Hatchery fish were stocked as early as 1902; since then, only Willamette stocks have been released into the McKenzie. Since 1962, construction of Cougar Dam on the South Fork of the McKenzie River has blocked access to approximately 25 miles of some of the most productive spawning habitat available historically. Adult fish were initially (1962-1964) trucked above the dam after construction was completed, and then released but this practice was discontinued because of difficulties capturing adults below the dam and low collection efficiencies and high mortality in the juvenile bypass system (ODFW 1990e).

Coast Fork Willamette Subpopulation: Native spring chinook have existed, but were never abundant, in the Coast Fork Willamette River subbasin (ODFW 1992). Two dams (Dorena and Cottage Grove) currently block upstream access to spawning areas. Also, low flows and warm

water discharge from the two dams are thought to reduce the production of chinook salmon below the dams (ODFW 1990d).

4.1.1.1.1 Historic Distribution

Table 4-1 summarizes pre-dam and current natural spawning distributions of spring chinook salmon in the Willamette River basin. Spring chinook salmon originally had access to approximately 1,400 miles of stream habitat within the Willamette River basin as estimated by NMFS through summation of stream miles from maps in the early 1970s (Max Smith, EWEB, personal communication, October 1995). Mattson (1948) gives the earliest accounting of the relative productivity of subbasins located above Willamette Falls. At that time, production had not yet been impacted as a result of extensive dam construction throughout the basin, and essentially all production was thought to have been of natural origin because the survival of hatchery fish was estimated to be extremely low (Wallis 1961; Howell et al. 1988).

Spring chinook salmon are thought to have spawned historically in the Coast Fork Willamette, Middle Fork Willamette, McKenzie, Calapooia, Santiam, and Molalla rivers (Connolly et al. 1992 a and b; Howell et al. 1988; and Wevers et al. 1992 a and b). In addition, small numbers of spring chinook may have spawned in tributaries of the Pudding River (e.g., Abiqua Creek; Wevers et al. 1992a) and in the upper reaches of Gales Creek in the Tualatin River (Murtagh et al. 1992b).

Both the McKenzie River and the Middle Fork Willamette River basin were major natural production areas for spring chinook salmon in the upper Willamette River basin. The McKenzie produced an estimated 40 percent of the spring chinook spawners above Willamette Falls prior to dam construction throughout the Willamette River basin (Mattson 1948). By 1959, approximately 50 percent of the run over the falls returned to the McKenzie River (Willis et al. 1960). The spring chinook run into the Middle Fork Willamette River was estimated to comprise 21 percent of the spawning population above Willamette Falls in 1947 (Mattson 1948).

The Santiam River subbasin received 35 percent of the 1947 spring chinook salmon escapement above Willamette Falls, of which approximately 23 percent returned to the North Santiam River system and 12 percent to the South Santiam system (Mattson 1948). The mainstem Santiam River below the confluence with the North and South Santiam rivers is also believed to have supported spawning of spring chinook salmon (Wevers et al. 1992).

Willis et al. (1960) reported substantial natural production potential remaining in the Santiam subbasin in the late 1950s. The North Santiam River was believed to be second only to the

Table 4-1. Pre-dam and current distribution of spring chinook salmon in the Willamette River basin based on a review of Mattson (1948) and ODFW subbasin fish management plans (Howell et al. 1988; Connolly et al. 1992a, 1992b; Murtagh et al. 1992a, 1992b; Rien et al. 1992; Wevers et al. 1992a, 1992b).

| | | Current Distribution | |
| | | Natural | Hatchery Releases |
Location	**1947 Distribution [a]**	**Natural**	**Hatchery Releases**
East Fork Willamette River			
Mainstem	Few [1]	None	
Row River	Few [1]	None	
Middle Fork Willamette River			
Mainstem	Present	Few [2]	Present [5]
Fall Creek	Present	Few [3]	Present [5]
Little Fall Creek	Unknown	Few [4]	
North Fork	Present	None	
Salmon Creek	Present	None	
Salt Creek	Present	None	
McKenzie River			
Mainstem	Present	Present	Present
Mohawk River	Present	Few [6]	
Camp Creek	Present	Few [6]	
Gate Creek	Present	Present	
Blue River	Present	Few [7]	Present
South Fork	Present	Present	Present [8]
Horse Creek	Present	Present	Present [8]
Lost Creek	Present	Present	
Calapooia River	Present	Few [9]	Present [9]
Santiam River			
South Santiam River	Present		
Mainstem	Present	Present	Present
Thomas Creek	Unknown	Present	

Table 4-1. Pre-dam and current distribution of spring chinook salmon in the Willamette River
basin based on a review of Mattson (1948) and ODFW subbasin fish management
plans (Howell et al. 1988; Connolly et al. 1992a, 1992b; Murtagh et al. 1992a, 1992b;
Rien et al. 1992; Wevers et al. 1992a, 1992b).

| | | Current Distribution | |
Location	1947 Distribution [a]	Natural	Hatchery Releases
Crabtree Creek	Unknown	Present	Present [9]
Hamilton Creek	Unknown	None	Present [9]
Middle Fork	Present	None	
Quartzville Creek	Present	None	
North Santiam River			
Mainstem	Present	Present	Present
Marion Creek	Present	None	
Little North Fork	Present	Present	Present [10]
Blowout Creek	Present	None	
Breitenbush River	Unknown	None	
Mill Creek	Present		
Molalla River			
Mainstem	Present	Unknown	Present [11]
Pudding River			
Mainstem	Unknown	Unknown	
Abiqua Creek	Present	Unknown	Present [11]
North Fork	Unknown	Unknown	Present [11]
Table Rock Fork	Unknown	Unknown	Present [11]
Tualatin River			
Gales Creek	Unknown	None	
Clackamas River			
Mainstem	Present	Present	Present
Eagle Creek	Present	Present	
Fish Creek	Present	Present	

Table 4-1. Pre-dam and current distribution of spring chinook salmon in the Willamette River basin based on a review of Mattson (1948) and ODFW subbasin fish management plans (Howell et al. 1988; Connolly et al. 1992a, 1992b; Murtagh et al. 1992a, 1992b; Rien et al. 1992; Wevers et al. 1992a, 1992b).

| | | Current Distribution | |
Location	1947 Distribution [a]	Natural	Hatchery Releases
Roaring River	Present	Present	
Collawash River	Present	Present	
Hot Springs Fork	Present	Present	
Willamette River			
Mainstem			
Above Willamette Falls	Unknown	Unknown	Present
Below Willamette Falls	None	None	Present

a. Areas indicated are those specifically mentioned in reports reviewed. Additional adjacent areas within subbasins may also have been production areas. Relative productivity (i.e., Few or Major) is indicated where this information was provided.

[1] Probably never abundant (Willis et al. 1960).

[2] Successful spawning below Dexter Dam is minimal due to release of water above 12.8°C during egg incubation (Connolly 1992a); spawning occurs upstream of reservoir by transported adults.

[3] Little spawning occurs because of sedimentation and alteration of water flow and temperature below Fall Creek Dam (Connolly 1992a); spawning occurs upstream of reservoir by transported adults.

[4] Spawning may occur intermittently during high flow years; annual runs probably do not exceed ten adults and may be hatchery strays (Connolly 1992a).

[5] A large portion of the escapement does not enter the adult collection facilities at Dexter and Fall Creek dams and may contribute to natural production downstream (Connolly 1992a).

[6] These areas are not suitable for spring chinook production because of lack of holding pools, warm water, and low flow during the spawnable period (Howell et al. 1988).

[7] Adults were observed for the first time in recent years below Blue River Dam in 1986 (Howell et al. 1988); these resulted from Blue River Reservoir rearing program initiated in 1983.

[8] Hatchery releases discontinued since 1991.

[9] Fingerlings, smolts, and adults have been stocked to restore the run, but few returns have been realized because of continuing passage problems, low flows and limited rearing habitat (Wevers et al. 1992a).

[10] ODFW Salmon and Trout Enhancement Program (STEP) egg hatching box release only (Wevers et al. 1992b); few if any returns are likely to occur from these releases.

[11] Willamette stock fingerlings, smolts, and adults have been released in the Molalla and Pudding River subbasins to re-establish runs and to provide a fishery in these streams; success of this program in re-establishing runs has not yet been evaluated (Wevers et al. 1992a).

McKenzie River for production of chinook salmon populations in the Willamette River system at that time. From 1952 through 1959, an average of 1,400 adult chinook salmon were collected at the hatchery trap at Minto on the North Santiam River. The Little North Santiam River was estimated to be capable of supporting 5,000 to 10,000 fish. In a 20 September 1946 spawning survey, observers on the Little North Santiam River counted 801 adult salmon in the 8 miles of stream from the mouth up to Elkhorn Falls, and counted 273 chinook salmon redds in the same reach on 9 October 1954 (Willis et al. 1960).

4.1.1.1.2 Present Distribution

Much historic spawning and rearing habitat has been inundated by reservoirs, or is not presently accessible above USACE dams (Figure 4-5). Bennett (1994) observed that dams constructed in the 1950s and 1960s on the Santiam, Middle Fork Willamette, and McKenzie rivers above Willamette Falls blocked over 400 stream miles that were originally the most important spawning areas for native chinook salmon.

Substantial amounts of high quality habitat remain, and the ODFW lists the McKenzie River, the North Santiam and Little North Santiam rivers, and the Clackamas River above North Fork Dam as essential habitat for spring chinook salmon production in the Willamette River basin (ODFW 1993). Nearly all of the present-day natural production of spring chinook salmon in the Willamette River basin occurs in the McKenzie, Santiam, and Clackamas rivers (Willis et al. 1995). At present the only significant natural production of spring chinook salmon occurs in the McKenzie River basin (64 FR 14308). Nicholas et al. (1995) suggested that a self-sustaining population may also exist in the North Santiam River basin.

Limited natural production may occur in other subbasins including the Calapooia, Molalla and Pudding rivers, where releases of hatchery spring chinook have been made in an effort to re-establish naturally reproducing populations. However, there is no evidence that these populations have become self-sustaining. The Middle Fork Willamette River and mainstem Willamette River do not provide much habitat suitable for spring chinook spawning (ODFW 1990b, 1990f). Some limited natural spawning may occur in Little Fall Creek, a tributary of Fall Creek, during high flow years (ODFW 1990f; Connolly et al. 1992a), and in the mainstem Willamette River above the mouth of the McKenzie River (Rien et al. 1992).

Most of the natural spawning of spring chinook in the McKenzie subbasin currently takes place upstream of Leaburg Dam (completed in 1930) located at River Mile (RM) 35. Homolka and Downey (1995) conducted extensive spawning ground surveys of the upper McKenzie River above Leaburg Dam in 1992. Redds were observed in the upper McKenzie River tributaries of

Figure 4-5.   Map of spring chinook habitat blocked in the Willamette River basin (from Cramer et al. 1996).

Horse Creek and Lost Creek early in the spawning season (i.e., on the last day of August); spawning progressed downstream over time to the area below Leaburg Dam.

4.1.1.2 Population Trends

Population trends of upper Willamette spring chinook have been influenced strongly by dam construction and hatchery production, as described below. Because of the strong hatchery influence on McKenzie River spring chinook since the 1940s, the following population trends reflect combined abundances of hatchery and naturally produced fish.

4.1.1.2.1 Run and Catch Sizes

A major portion of the spring chinook run entering the Willamette River is destined for portions of the basin above Willamette Falls. Fish have been counted as they pass through the fish ladders at the falls since 1946. Approximately 55,000 fish were counted that year during the period of April through June, and 45,000 fish in 1947 (Mattson 1948). Counts of adult spring chinook over Willamette Falls were relatively steady, at approximately 26,000 fish during the 1950s, increased to approximately 32,000 to 34,000 fish during the 1960s and 1970s, and increased again up to an average of approximately 63,000 fish during the late 1980s and early 1990s (Figure 4-6). Table 4-2 summarizes and compares run size estimates for 1947, which is before construction of the Willamette Project dams on the primary spring chinook river systems, with current conditions as defined by the period 1980-1989. Estimated run sizes before 1946 vary depending on data and assumptions used. Mattson (1948) estimated that run sizes throughout the Willamette system in the 1920s were about five times greater than in 1946 and 1947. The combined historic annual run size of spring chinook salmon in the Willamette and Sandy River basins (i.e., Upper Willamette Chinook Salmon ESU plus part of Lower Columbia Chinook Salmon ESU) is estimated to have been on the order of several hundred thousand adults (ODFW 1995a).

The estimated run size of spring chinook into the McKenzie River subbasin from 1945-1960 was about 18,000 adults, with a high of 38,000 in 1953 and a low of 6,000 in 1950 (USACE 1995a). Estimates of spring chinook salmon returns to the McKenzie River since 1970 have comprised between 10.9 percent (1984) and 25.5 percent (1993) of the estimated total escapement over Willamette Falls and have remained relatively steady (Table 4-3). Estimated numbers averaged 5,861 fish (16.7%) during the period 1970-79, 6,183 fish (13.5%) during 1980-1989, and 6,480 fish (17.1%) during 1990-1994 (Table 4-3). An average of 2,599 fish escaped over Leaburg Dam and into natural production areas in the upper McKenzie River during the period
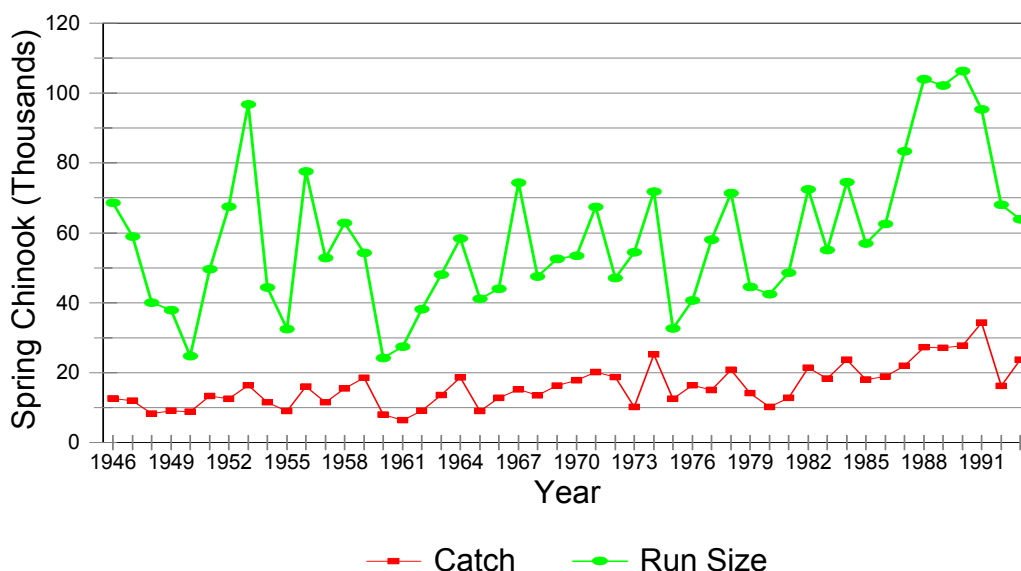
Figure 4-6.   Number of Spring Chinook entering the Willamette River and catch in recreational
fisheries of the lower Willamette and lower Clackamas rivers, 1946-1993 (from Cramer
et al. 1996).

1970-1979, or 44 percent of the estimated total spring chinook run returning to the McKenzie
River. Escapement over Leaburg Dam averaged 2,493 fish during the period 1980-1989 and
2,950 fish during 1990-1998. However, the averages were influenced by the 1990, 1988, and
1991 runs, which were the first, second, and third largest, respectively of the period of record
since 1970. Runs have been consistently smaller than average after 1993, and numbers escaping
above Leaburg Dam averaged 1,529 fish from 1994 through 1998 (Table 4-3).

Current levels of natural production in reaches above Leaburg Dam were estimated based on the
proportion of adipose fin-clipped fish among chinook counted passing the dam compared to the
proportion among fish returning to the McKenzie Hatchery. The estimates between 1994 and
1998 ranged from 54 percent in 1994 to 84 percent in 1997 (Table 4-3); all of the lower river
spawners were of hatchery origin (ODFW data, Springfield).

The abundance of naturally-produced juvenile chinook in the McKenzie River has also been
indexed from migrant trapping at Leaburg Dam. The abundance of smolts in the McKenzie
River has been correlated with the number of adults above Leaburg Dam that produced them
(Figure 4-7). There is no indication of a density-dependent reduction in survival, even up to
adult escapements of 9,000 salmon above Leaburg Dam (including trucked adults). Since
hatchery fish generally compose about half of the naturally spawning population, they appear to
still be viable.

Table 4-2. Pre-dam (minimum estimates of natural production) and current (natural and hatchery) run sizes of spring chinook salmon in major production areas of the Willamette River basin. Note that pre-dam estimates are not representative of pre-European settlement run sizes (from Willis et al. 1995).

Location	Pre-Dam (1947)[1]		Current (1980-1989)[2]	
	Run Size	Percent	Run Size	Percent
Fish Passing Willamette Falls				
Middle Fork Willamette River	2,550	21	8,748	41
McKenzie River	4,780	40	5,307 [7]	25
Calapooia River	30	< 1	0	0
Santiam River	4,130	34	5,914	28
Molalla River	550	5	28	< 1
Mainstem sport catch (above Willamette Falls)[5]	Unknown	Unknown	1,512	7
Fish unaccounted for above Willamette Falls [3]	32,960	73 [6]	22,991	52 [6]
Total Willamette Falls Escapement	**45,000**	**76**	**44,500**	**63**
Fish Below Willamette Falls				
Mortality below Willamette Falls [4]	Unknown	Unknown	200	< 1
Clackamas River Escapement	2,000	3	8,700	12
Mainstem sport catch (below Willamette Falls)	12,000	20	16,800	24
Total Willamette System Escapement	**59,000**	**100**	**70,200**	**100**

1. Estimated 1947 returns among subbasin located above Willamette Falls from Mattson (1948) and estimated returns to the Willamette and Clackamas rivers in 1947 from Steve King (ODFW, personal communication), and from data used for ODFW and WDFW (1995) and for Bennett (1994).

2. Based on ten-year average runs during 1980-89 from data reported in ODFW and WDFW (1995) and in Bennett (1994). Subbasin returns include hatchery returns and sport catch.

3. Difference between Willamette Falls escapement (ODFW and WDFW 1995) and fish for which there is an accounting (Subtotal above Willamette Falls)

4. ODFWs recent (since 1970) estimates of mortality below Willamette Falls are for a relatively small area within ten miles below the falls. Some additional mortality likely occurs elsewhere below the falls. Mortality below the falls was probably much higher in 1947 as a result of poor passage conditions prior to the late 1970s (Bennett 1994) and relatively high levels of pollution (Merryfield and Wilmot 1945, Merryfield et al. 1947). The effect of accounting for this unknown mortality in 1947 would likely be to substantially increase estimates of total escapement into the Willamette River basin.

5. Includes sport catch in the Middle Fork and Coast Fork river subbasins. Sport catch was not estimated by Mattson (1948).

6. Percentage of Willamette Falls escapement.

7. Includes escapement over Leaburg Dam.

Table 4-3. Estimated return of spring chinook to the McKenzie River and escapement above Leaburg Dam (ODFW data, Springfield).

Run Year	Total Escapement to McKenzie River	% of Total Escapement Over Willamette Falls	Total Escapement Leaburg Dam	Estimated % of Escapement Over Leaburg Dam Spawning Naturally
1970	4,787	14.0%	2,991	
1971	6,323	14.2%	3,602	
1972	3,770	14.4%	1,547	
1973	7,938	18.9%	3,870	
1974	7,840	17.6%	3,717	
1975	3,392	17.8%	1,374	
1976	4,275	19.3%	1,899	
1977	9,127	22.8%	2,714	
1978	8,142	17.1%	3,058	
1979	3,018	11.3%	1,219	
Mean 1970-79	**5,861**	**16.7%**	**2,599**	-------
1980	4,154	15.4%	1,980	
1981	3,624	12.0%	1,078	
1982	5,413	11.7%	2,241	
1983	3,377	11.0%	1,561	
1984	4,739	10.9%	1,000	
1985	4,930	14.3%	825	
1986	5,567	14.2%	2,061	
1987	7,370	13.4%	3,455	
1988	12,637	17.9%	6,753	
1989	10,020	14.5%	3,976	
Mean 1980-89	**6,183**	**13.5%**	**2,493**	-------
1990	12,743	17.9%	7,115	
1991	11,553	22.0%	4,359	
1992	8,976	21.4%	3,816	
1993	8,148	25.5%	3,617	
1994	2,992	11.5%	1,526	54%
1995	3,162	15.4%	1,622	57%
1996	3,640	16.8%	1,445	76%
1997	3,110	11.6%	1,176	84%
1998	3,997	11.6%	1,874	77%
Mean 1990-98	**6,480**	**17.1%**	**2,950**	-------
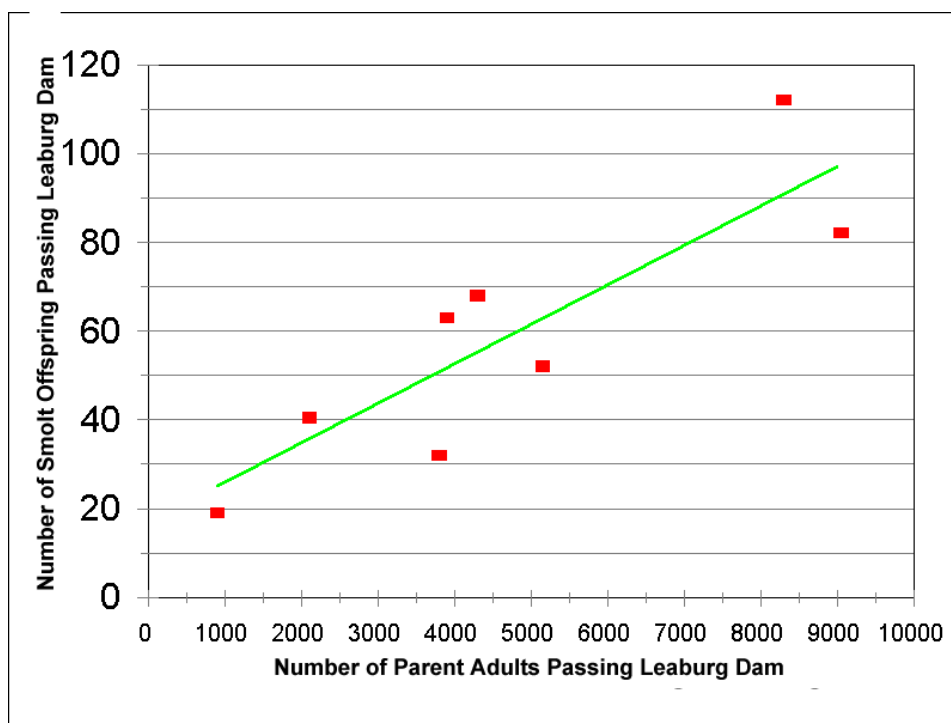
Figure 4-7.   Scatter plot of the number of chinook smolts collected passing Leaburg Dam on the McKenzie River versus the number of adults in the parent run passing upstream of Leaburg Dam. Smolt production was indexed as the number of downstream migrants passing Leaburg from August in their first year of life through May in their second year. (from Cramer et al. 1996).

Systematic aerial surveys began for fall chinook spawning on the Santiam River system in 1970. It was difficult to distinguish between spring chinook and fall chinook redds because so much introgression of fall chinook spawning into major areas once used by spring chinook had occurred by 1970, that only spawning activity in the uppermost reaches of the system could be attributed to spring chinook salmon. Redds observed upstream of Stayton in the North Santiam River were most likely to have been attributable to spring chinook; counts ranged between 0 and 52 redds during the 1970-1994 period (Willis et al. 1995). Redd counts upstream of the confluence with the Little North Santiam ranged from 80 to 112 during 1991-1994. Redd counts in the South Santiam River upstream of Lebanon Dam ranged from 10 to 144 during 1970-1993 and are most likely attributable to spring chinook (Willis et al. 1995).

The Little North Santiam River has currently the most substantial production potential of all the currently accessible streams in the Santiam River system. Annual midsummer snorkel surveys of the Little North Santiam River during 1991-1995 indicated adult counts varied from 0 in 1994

and 1995 to 242 in 1991 (Haxton and Hunt 1994, 1995). This tributary is not subjected to water temperature effects of the storage reservoirs. Limited snorkel surveys of the mainstem North Santiam River near Stayton indicated that a fair level of natural production was taking place in that area; the majority of juveniles are presumed to be spring chinook, although a few fall chinook salmon currently ascend the river above Stayton (Willis et al. 1995).

There is also substantial natural production of spring chinook in the Clackamas River, which enters the Willamette River below Willamette Falls, but is included as part of the Upper Willamette Chinook ESU. The area in the upper Clackamas River above North Fork Dam is the principal natural production area within that subbasin. Returns of spring chinook salmon to the Clackamas subbasin and subsequent escapement above North Fork Dam increased substantially following initiation of the Clackamas Hatchery program (Figure 4-8). This coincidence suggests that hatchery fish comprise a large proportion of the fish passing above North Fork Dam.

Counts of juvenile spring chinook salmon passing North Fork Dam indicate natural spawning is still occurring above the complex of dams on the Clackamas River (Figure 4-9). Juvenile chinook are counted migrating downstream through the North Fork migrant bypass system in every month of the year. Most chinook juveniles counted at the North Fork downstream facility, based on appearance, are smolts. The bulk of the migration occurs in April and May. Juvenile chinook counts have increased with spawner escapement since the early 1980s.
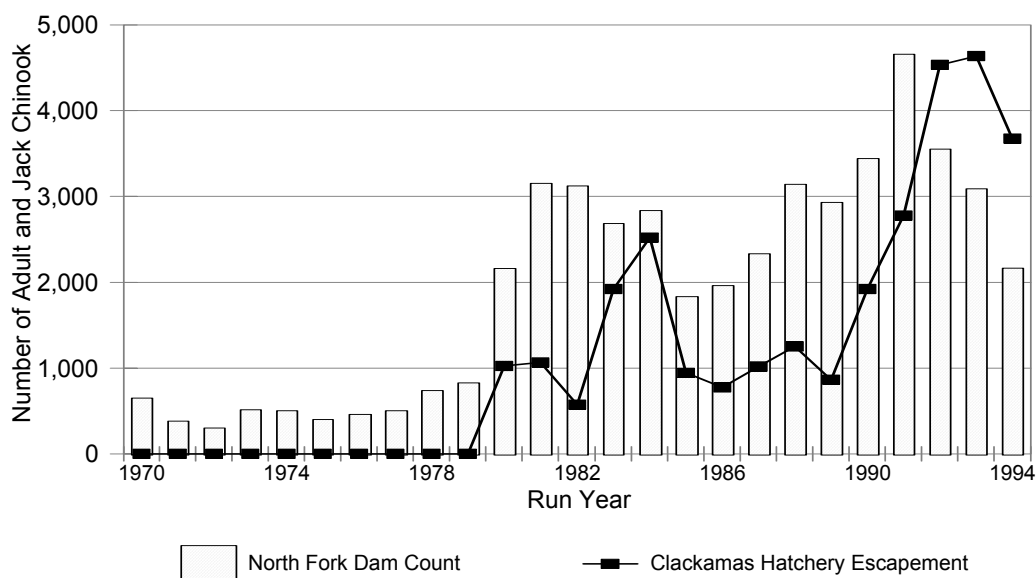
Figure 4-8.   Adult spring chinook salmon passage over North Fork Dam on the Clackamas River in relation to Clackamas Hatchery escapement (from Cramer et al. 1996).
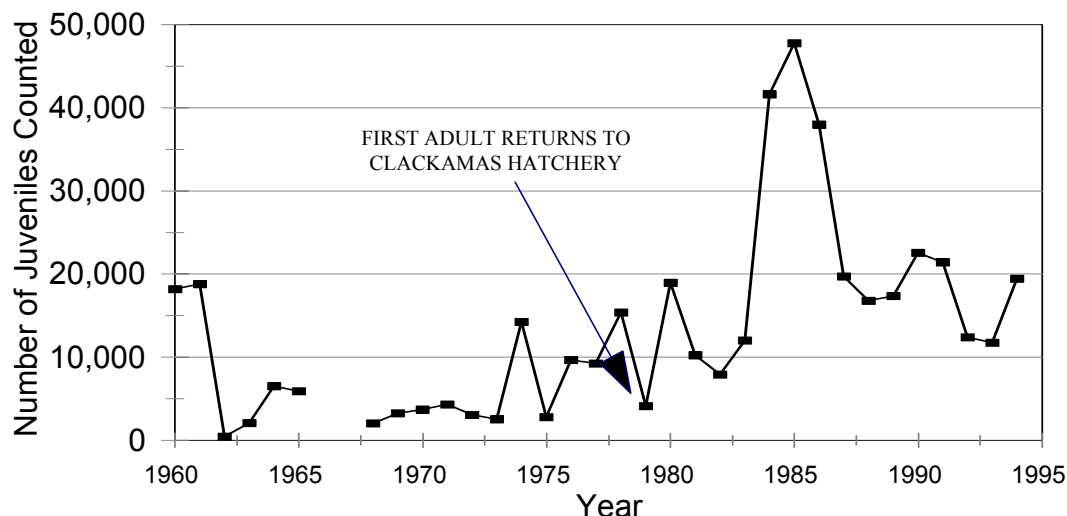
Figure 4-9.   Number of juvenile chinook salmon counted in the downstream migrant collection
                facility at North Fork Dam on the Clackamas River (from Cramer et al. 1996).

Long-term trends in escapement of spring chinook salmon to the Upper Willamette River ESU
have been mixed, ranging from slightly upward to moderately downward. The overall size of the
Willamette spring chinook salmon run has fluctuated annually, but has not changed significantly
on average since 1946 (Figure 4-6). The goal of 100,000 spring chinook of Willamette River
origin returning to the Columbia River was first achieved in 1988, largely as the result of
increased hatchery production, improved hatchery practices and good levels of ocean
productivity.

Short-term trends in abundance are all strongly downward. Since 1991, the size of the run has
followed the trend of reduced survival for all lower Columbia River spring chinook stocks. This
decline is partly attributable to poor ocean productivity conditions in the near-shore margin
(ODFW and WDFW 1995). The high proportion of hatchery fish in the total return and on
spawning grounds indicate that populations of chinook salmon in the ESU are not self-
sustaining. ODFW identified spring chinook salmon in the McKenzie River as the only
remaining, naturally reproducing subpopulation (64 FR 14322). Most naturally spawning
chinook in other areas above Willamette Falls appear to have been influenced heavily by
hatchery fish.

Cramer et al. (1996) evaluated the fate of chinook salmon adults after they entered the
Willamette River, during the mid 1970s to mid 1990s (Figure 4-10). Willamette spring chinook
contribute extensively to ocean and in-river fisheries (Cramer et al. 1996), and a large share of

Components of Willamette Spring Chinook Escapement
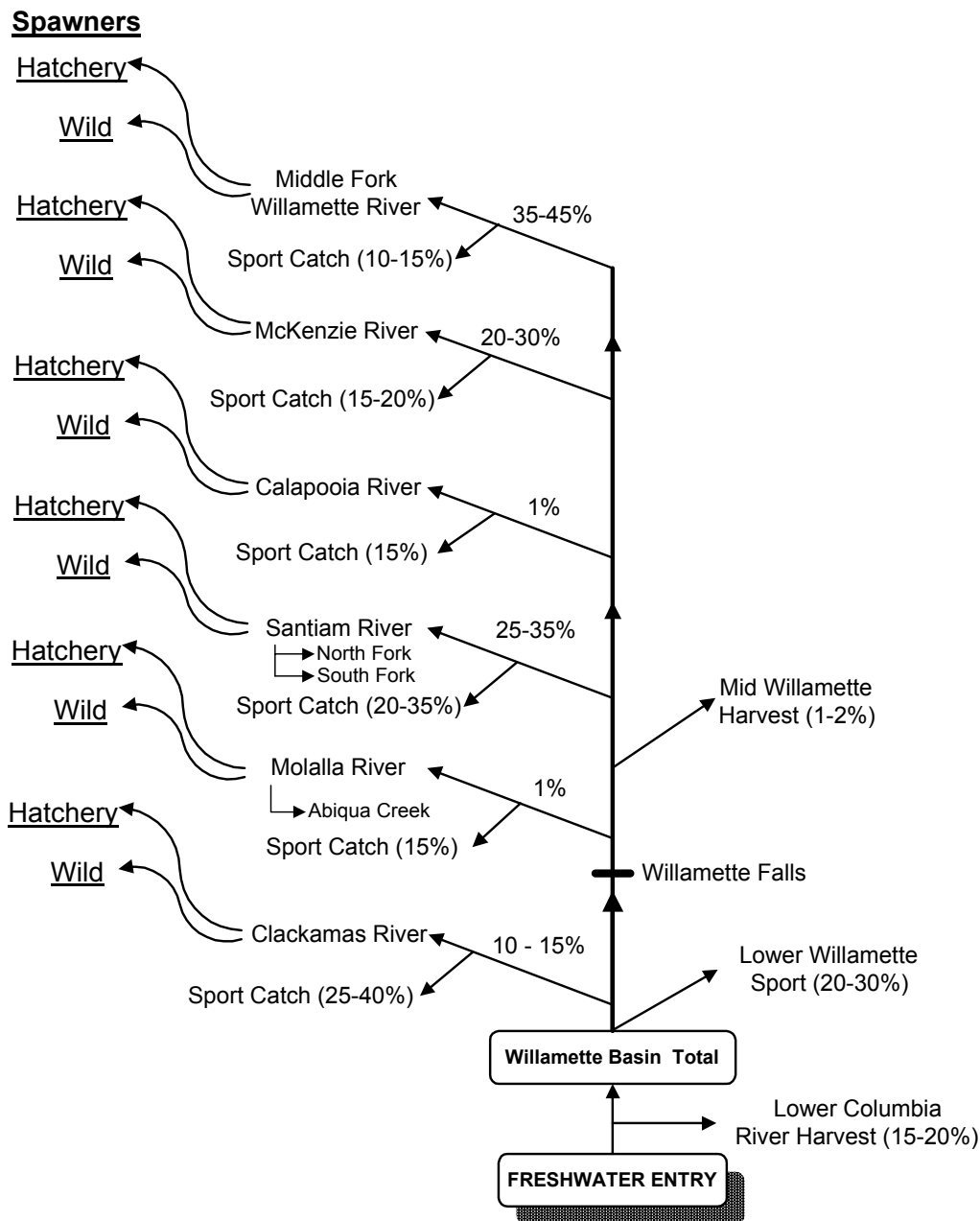
Figure 4-10. Diagram showing most major destinations of the spring chinook run entering the Willamette River (from Cramer et al. 1996). Harvest rates in subbasins are approximate for 1975-1990. Run sizes above Willamette Falls are expressed as percentages of the counts at the falls.

the run entering freshwater is captured in sport and commercial fisheries: 15-20 percent in the lower Columbia, 20-30 percent in the lower Willamette, and 10-35 percent in tributaries. Catch numbers in the recreational fisheries below Willamette Falls have generally followed the run size passing Willamette Falls. It was estimated that harvest rates on Willamette spring chinook in the ocean and river combined during 1975-1990 (Figure 4-11) have probably exceeded the maximum sustainable level for naturally-produced fish in most years. Overall harvest rates on fish destined to mature at age 5 were estimated to range between 62 percent and 70 percent on average for the 1984-1989 brood years. These harvest rates include the proportions of fish removed in the ocean at age 3 and 4, and in the river at age 5. Although harvest rates remained relatively stable between years, estimated smolt-to-adult survival of hatchery smolts varied several fold for the 1975-1989 brood years. High harvest rates coupled with low ocean survival may have resulted in substantial overharvest of Willamette spring chinook in many years.

4.1.1.2.2 Hatchery Contribution To Natural Production

Before the mid-1950s, the progeny of returning spring chinook to the Willamette River was from naturally produced adults; since the mid-1950s, hatchery produced runs have been predominant (Howell et al. 1985a). Hatchery practices prior to circa 1960 were generally ineffective: Wallis (1961a) reviewed hatchery records and found no evidence to indicate that operation of the old McKenzie Hatchery had made any significant contributions to the returns of spring chinook salmon. Improved hatchery facilities, hatchery practices, and disease control procedures resulted in major, increased contributions of hatchery fish to adult returns beginning about 1975. By 1988, the run size of Willamette spring chinook salmon had increased to more than 100,000 fish entering freshwater. This was the first time that this level of return had been exceeded since 1953. Returns greater than 100,000 fish continued through 1991, largely because of the hatchery program. Currently, the annual spring chinook run sizes in the Willamette River are reduced below 100,000 adults, which may be attributable in large part, to poor ocean production conditions (ODFW and WDFW 1995).

The Fish Commission of Oregon (FCO) evaluated the contribution of hatchery spring chinook to the overall Willamette adult return using hatchery fish marked with oxytetracycline from the 1970 brood. Results reported in Collins and Massey (1975) and in Collins (1976) indicated that 24 percent of the mixed-subbasin age-4 adults and 44 percent of the returning age-5 adults were of natural or "unknown" origin. The results of the 1970-brood study provided only maximum estimates of the proportion of unmarked (naturally produced) adults in the runs of age-4 and age-5 fish in the 1974 and 1975 return years, respectively. The percentage of wild fish in the Willamette run was estimated by ODFW (1990c) to be between 5 and 15 percent.
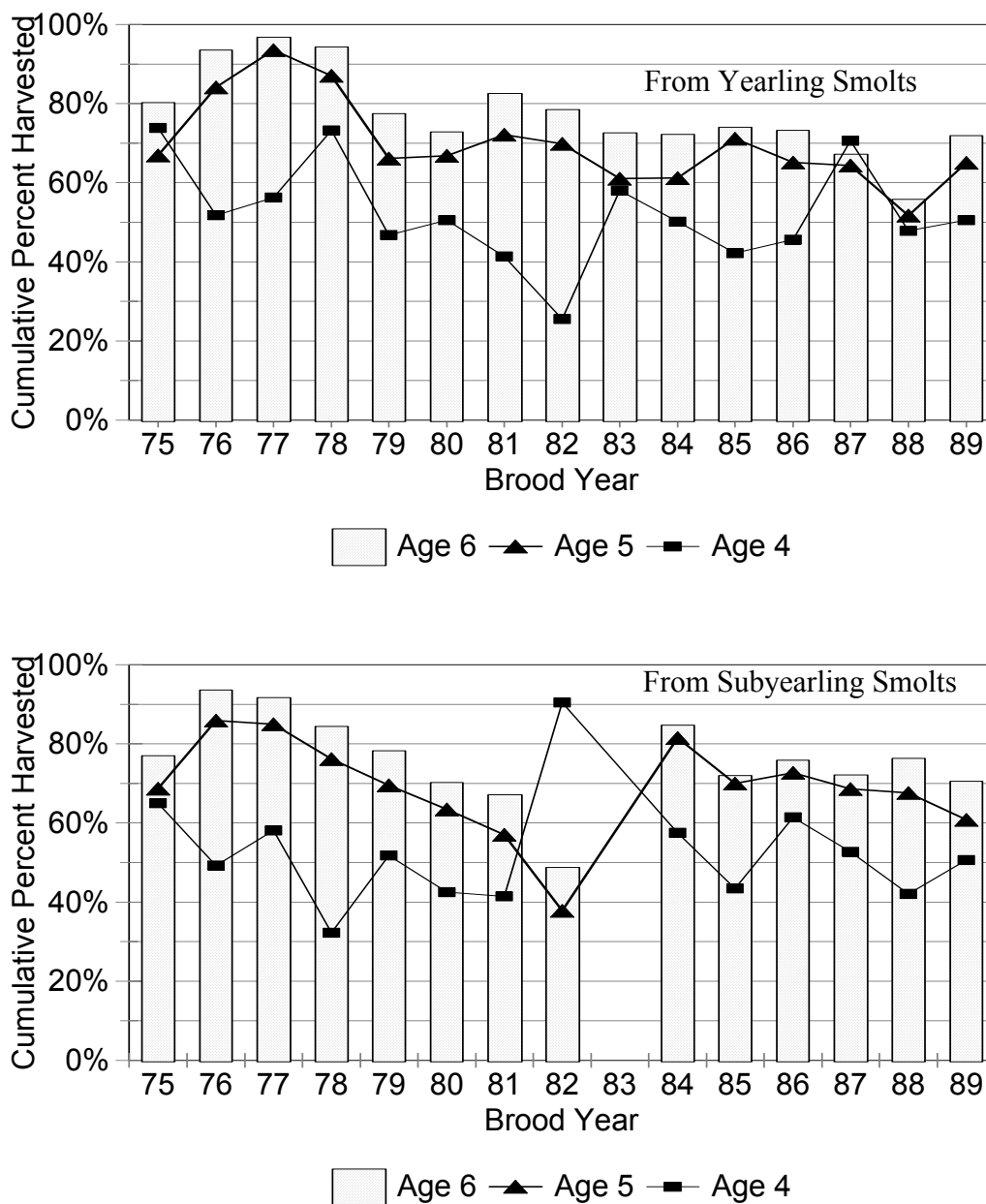
Figure 4-11.　Cumulative percentage of a cohort harvested in all fisheries by the time it is ready to spawn (ocean harvest at each age and in-river harvest on the spawning run are included). Data are averages for the 1984-1989 broods from all Willamette River basin hatcheries. Harvested fish are distinguished by whether they were released initially as yearling (top) or as sub-yearling smolts (bottom) (from Cramer et al. 1996).

The relative contribution of hatchery production has also been estimated by counting juveniles as they migrate downstream past Willamette Falls and looking for physical features characteristic of hatchery fish. Only 15.4 percent and 2.8 percent of the spring chinook salmon smolts sampled at Willamette Falls in 1993 and 1994, respectively, appeared to be of natural origin (Cramer, PGE, personal communication, December 1995). However, the estimate may be inflated because of the presence of hatchery fish released as presmolts that become indistinguishable visually from naturally produced smolts.

While the present-day contribution of naturally produced spring chinook in the upper Willamette River basin as a whole appears to be quite small, the ODFW has estimated that up to 57 percent of the natural spawners in the McKenzie subbasin above Leaburg Dam are naturally produced fish (Mark Wade, ODFW, personal communication). The McKenzie River therefore appears to contain the most significant natural production out of all the subbasins located above Willamette Falls.

4.1.1.2.3 Current Hatchery Fish Releases

The original, temporary hatchery stations established in the Willamette River subbasins have since been upgraded into major fish propagation facilities. These facilities collectively produce approximately 5 million spring chinook salmon smolts (4-15 fish/lb) and additional presmolts for release into the Willamette River basin each year. Today, two hatcheries in the Clackamas River subbasin and five hatcheries located above Willamette Falls produce spring chinook salmon to meet mitigation requirements for the loss of spawning and rearing areas now blocked by dams (Table 4-4; Bennett 1994). All major subbasins have received substantial and continuing supplementation from hatchery fish (Figure 4-12). Additional details on recent hatchery release practices are provided in Willis et al. (1995). Off-station releases below Willamette Falls were reinitiated in 1991 and have continued at least through 1996. These fish are being held in net pens for a period of acclimation prior to release.

Adult hatchery chinook salmon have been released in 1993, and since 1996, above Cougar Reservoir with the goals of providing food for bull trout production and nutrients for ecosystem functions, and of developing a land-locked fishery in the reservoir. Relatively large numbers of chinook salmon juveniles have been observed to rear in the reservoir currently (ODFW 1999c).

Table 4-4. Willamette River basin spring chinook salmon production facilities (from Willis et al. 1995).

Production Facility	Subbasin Location	Annual Production[1]		Release Sites by Subbasin
		Smolts	Presmolts	
Clackamas	Clackamas	1,064,400	0	Clackamas
Eagle Creek	Clackamas	496,800[2]	185,700[3]	Clackamas
Marion Forks	North Santiam	497,100	87,100	North Santiam
South Santiam	South Santiam	352,700	0	South Santiam
McKenzie	McKenzie	907,500	306,600	McKenzie
		215,000[4]	566,800[5]	Middle Fork Willamette
Willamette	Middle Fork Willamette	373,400	1,109,100	Middle Fork Willamette
		262,700	545,500	South Santiam[6]
Dexter Ponds	Middle Fork Willamette	947,300	0	Middle Fork Willamette
		608,100	0	South Santiam
TOTAL		5,725,000	2,800,800	

1. Average releases for 1984-1993 broods (ODFW, John Leppink, personal communication) unless otherwise noted.
2. Through 1985 brood when smolt release program ended.
3. Through 1990 brood when egg collection ended.
4. Below Dexter Dam since 1991 brood.
5. Fall Creek Reservoir stocking; stocking of Fall Creek with fingerlings (approximately 1,000,000) each year has been cancelled; smolt releases are made now below the dam using fish reared at the Willamette Hatchery.
6. Through 1987 brood.

4.1.1.3 Life History

In addition to genetic sampling data, historic and current information regarding heritable traits of spring chinook salmon distributed among Willamette River subbasins support the determination that the upper Willamette River spring chinook salmon populations are essentially similar across the major subbasins. For example, Willis et al. (1995) found that time of spawning for both hatchery and natural spring chinook was uniform among the subbasins. In addition, there has been no indication that the genetic influence of early-spawning Carson stock (released during 1970-1975 at specific locations) was present in any of the subbasins (Willis et al. 1995). Outmigration timing and age at maturity have both been influenced by hatchery practices in the basin, but characteristics among naturally produced spring chinook still reflect historical patterns.
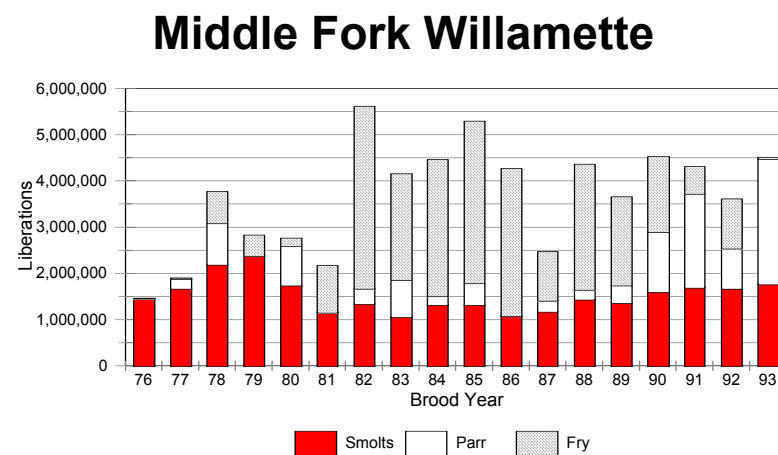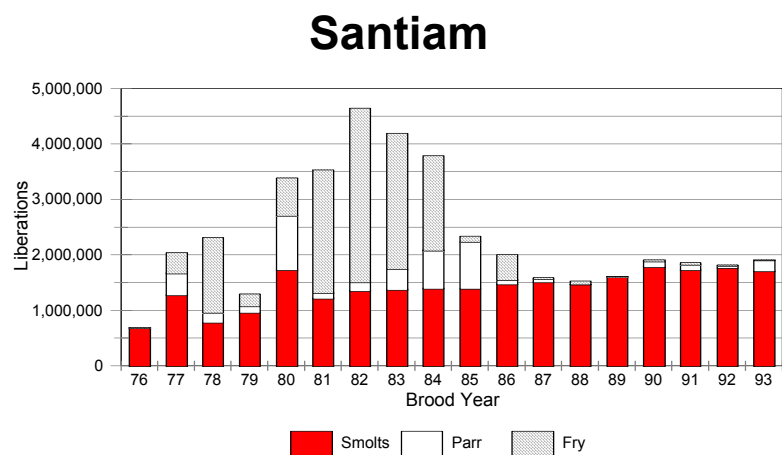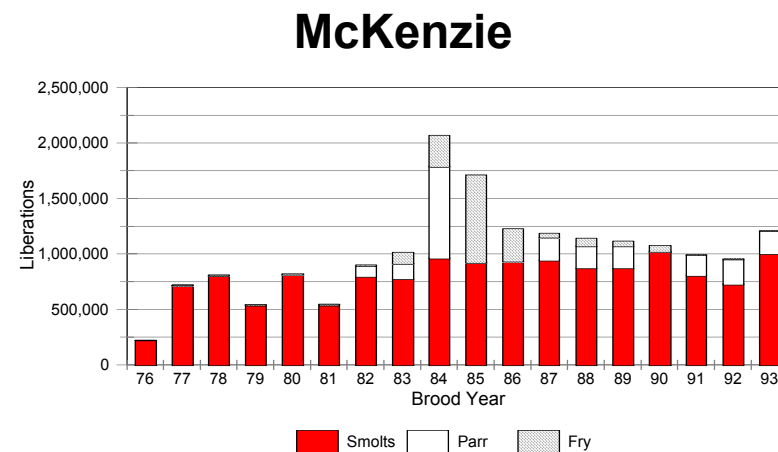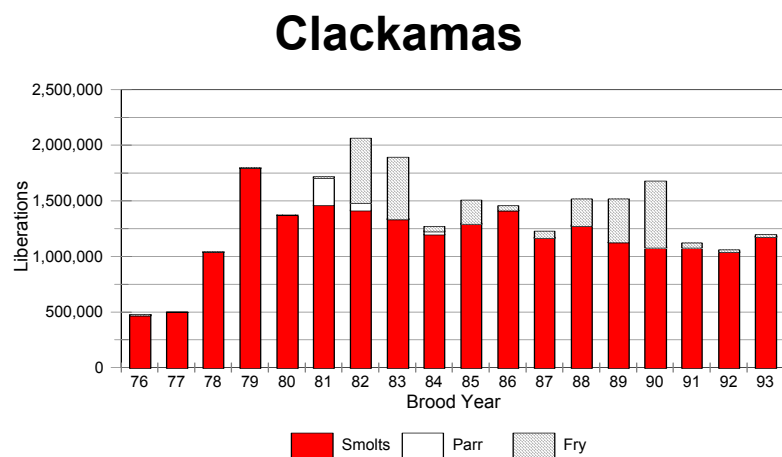
Figure 4-12.   Hatchery liberations of juvenile spring chinook salmon into subbasins of the Willamette River from the 1976-1993 broods (from Cramer et al. 1996).

4.1.1.3.1 Spawning

Wild spring chinook begin entering the Willamette River in February. The run peaks in April and entry is essentially completed by the end of May (ODFW 1992). Spawning occurs from August to early November. All spring chinook at Willamette River hatcheries spawn concurrently from early to mid-September until after the third week of October. Spawning peaks around the third week in September through the first week in October.

Spawn timing has shifted on the McKenzie and Clackamas rivers, but may not have changed significantly in the Santiam River subbasin (Willis et al. 1995). Spawning in the McKenzie River, where most present natural production occurs, began formerly in mid-August and lasted as late as the third week of October. Spawning activity is now largely confined to September but may extend in some years into mid-October (Willis et al. 1995). This change is reflected in the timing of egg collection in the McKenzie subbasin (Figure 4-13; Howell et al. 1988).

Spring chinook begin to enter the McKenzie River as early as mid- to late April when water temperatures begin to reach 11.1-12.2°C. Most of these pre-spawners hold in pools of cool water until they spawn in the fall. Homolka and Downey (1995) conducted extensive spawning ground surveys of the upper McKenzie River in 1992. They saw the first redds appearing in the upper McKenzie River tributaries (one redd each in Horse Creek and Lost Creek) on the last day of August. Inception of spawning appeared to progress downstream in the river over time, with the earliest redds seen in the headwaters. Initiation of spawning in the lower study transect (just below Leaburg Dam) occurred on 23 September in 1992. Based on combined data, the peak week of spawning of spring chinook salmon in the upper McKenzie River in 1992 occurred during the fourth week of September (Figure 4-14).

Willis et al. (1995) examined the handwritten notes of Leroy Ledgerwood, superintendent of the North Santiam Station (now the Marion Forks Hatchery), who recorded when spawning activity started, when it ended, and the peak date of spawning activity during 1919, 1922, and 1937. He indicated that spawning started on August 26-28 and ended between September 30 (1922) and October 31 (1919). The peak day of spawning activity occurred between September 12-21. Fewer than ten females were spawned on each of the last two days of spawning in 1922. The notes from Ledgerwood were consistent with later observations of Mattson (1948), who reported that the earliest spawning observed at rack sites in the Willamette River basin above the falls in 1947 occurred at the North Santiam rack on August 22. Spawning for hatchery purposes is now completed from mid-to-late September. Based on these observations, Willis et al. (1995) found no substantial change in spawn timing of hatchery spring chinook in the North Santiam River since 1919.
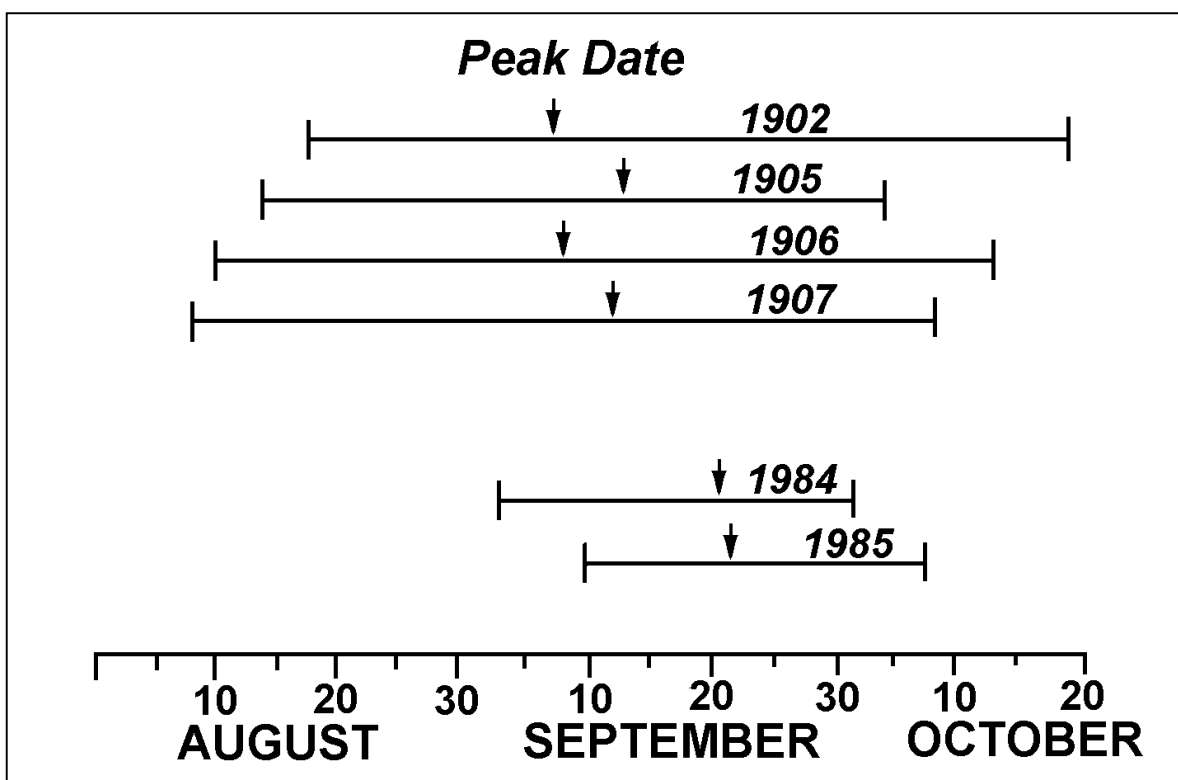
Figure 4-13.　Comparison of historical and recent timing of egg takes from spring chinook in the McKenzie River (from ODFW 1988).
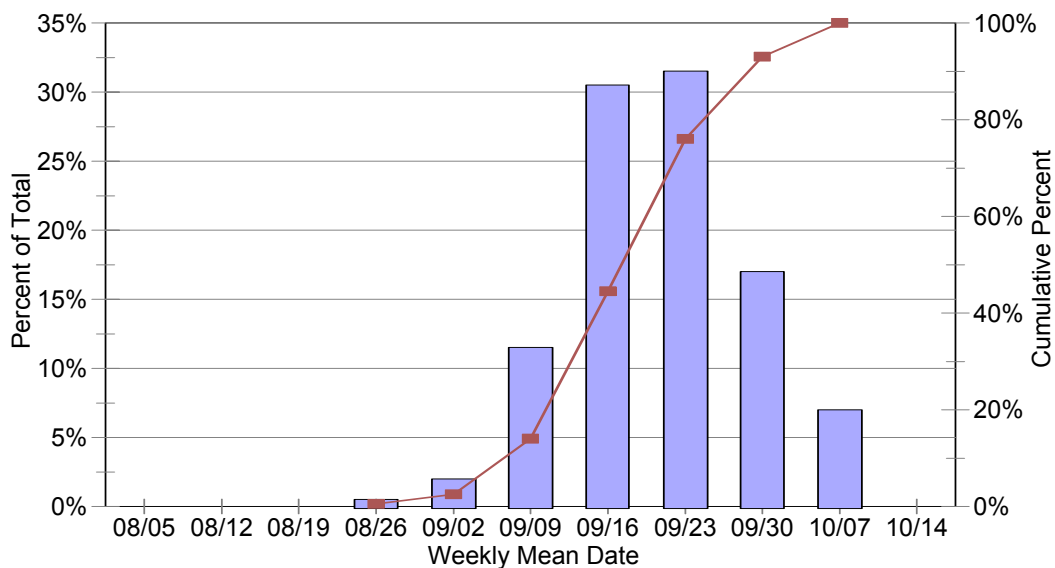
Figure 4-14.　Estimated percentage of spring chinook spawning in the McKenzie River during 1992 by weeks (from Homolka and Downey 1995).

4.1.1.3.2 Incubation

After spawning, spring chinook salmon eggs remain buried in the gravel for 1 to 4 months, depending on stream temperatures. Chinook eggs require 882 to 991 temperature units on average before hatching (1 temperature unit = 1 degree C above freezing for 24 h) (Beauchamp et al. 1983). The alevins, or yolk-sac fry, remain in the gravel for 2 to 3 weeks (depending on stream temperatures) after hatching (Wydoski and Whitney 1979). Elevated water temperatures during the fall below Cougar Dam in the South Fork McKenzie River, which accelerate embryonic development, have resulted in emergence occurring as early as December.

4.1.1.3.3 Juvenile Rearing

Naturally-produced juvenile chinook appear to emigrate soon after emergence in late winter and spring to both mainstem areas of major subbasins, including sections of the Willamette River, to rear until smoltification (ODFW 1990a). Murtagh et al. (1992a) noted that juvenile spring chinook in the Clackamas River did not appear to use the tributaries as rearing areas. Studies by Everest et al. (1987) in Fish Creek showed that most fry in the Clackamas system emigrate to the mainstem Clackamas River soon after emergence. Zakel and Reed (1984) observed the same type of behavior among spring chinook juveniles in the McKenzie River. Some juveniles use mainstem reservoirs as rearing areas (Murtagh et al. 1992a).

The ODFW has collected some seining data in the upper mainstem Willamette River each year since 1991, mostly during the summer (Mamoyac et al. 1995). Juveniles at various stages of development from fry to smolts have been collected from Peoria (RM 143) upstream to the mouth of the McKenzie River (RM 176). Of particular interest was the capture of numerous newly emerged chinook fry in April 1995 from Harrisburg (RM 162) up to Marshall Island (RM 170). These were concluded to be naturally produced fish because no hatchery releases of fish of this size were made at that time. It is likely that the fish originated from spawning in the lower McKenzie River.

Mainstem habitat below Peoria is less diverse than above, with fewer islands, fewer backwater areas, and more channel modification. Therefore, it may be less important as rearing habitat for spring chinook salmon.

Schreck et al. (1994) documented feeding activity and residence times of more than thirty-seven days in the mainstem Willamette River for hatchery spring chinook released in the upper Willamette River basin, particularly under low flow conditions.

4.1.1.3.4 Outmigration

Mattson (1962) reported three distinct migrations of juvenile spring chinook in the lower Willamette River (Lake Oswego area) that included a late winter-spring movement, a late fall-early winter movement, and a second spring movement. Less than half of the brood year emigrated as zero-age migrants (length 40-90 mm) in the late winter and early spring; less than half as age-1 fish (length 100-130 mm) in the fall, and less than a third as age-2 smolts (length 100-140 mm) during the spring. The largest smolts Mattson (1962) ever observed in his lower river sampling were 140 mm in fork length, a size that by current hatchery standards is small even for fall-released (as "1-year old") fish.

The smolt and fry migration patterns at Leaburg Dam in the McKenzie River averaged over the period 1986-1992 are shown in Figure 4-15. Fry migration timing appears to have changed over the years. Samples collected at various locations between 1948 and 1968 indicated that fry migration occurred primarily from March through June (Howell et al. 1988). Fry migration past Leaburg Dam since 1980 has occurred primarily during January through April, or earlier than in previous years. Likewise, fingerling migration peaked originally in January through March, and now peaks in October and November. Howell et al. (1988) suggest that the change in juvenile migration timing may be due to the release of warm water from impoundments above spawning areas during the fall incubation period, and consequent acceleration of fry emergence and movement. Hatchery smolts released above Leaburg Dam in March and November migrate past the dam within three to four days of release (Zakel and Reed 1984).

Portland General Electric (PGE) monitors passage of juvenile salmonids at their T.W. Sullivan hydropower plant located at Willamette Falls. Figure 4-16 shows the average proportion of hatchery and "natural" spring chinook salmon passing each month during 1992 through 1994. "Natural" fish are defined in the figure as those not having specific physical features characteristic of most hatchery fish. Only a portion of the flow and fish passing Willamette Falls passes through the Sullivan Plant, and the numbers used to develop Figure 4-16 are based on an expansion of fish captured at the plant by the estimated proportion of flow passing through the plant and by the time sampled (Cramer and Bullock 1995). Although data accuracy is uncertain, the data do provide an index of juvenile emigration timing. Both natural and hatchery fish passage peaked in March, with a subsequent and much smaller peak in late November (hatchery fish) and early December (natural fish). This timing is similar to the historic timing described above (Mattson 1962).
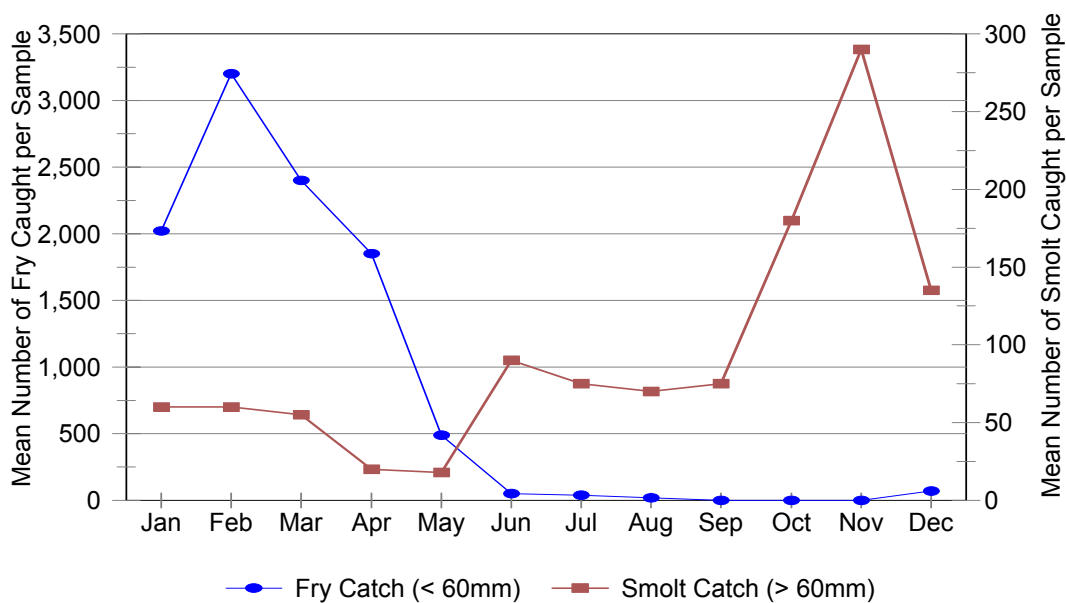
Figure 4-15.   Spring chinook smolt and fry migration at Leaburg Dam in the McKenzie River (from Willis et al. 1995).
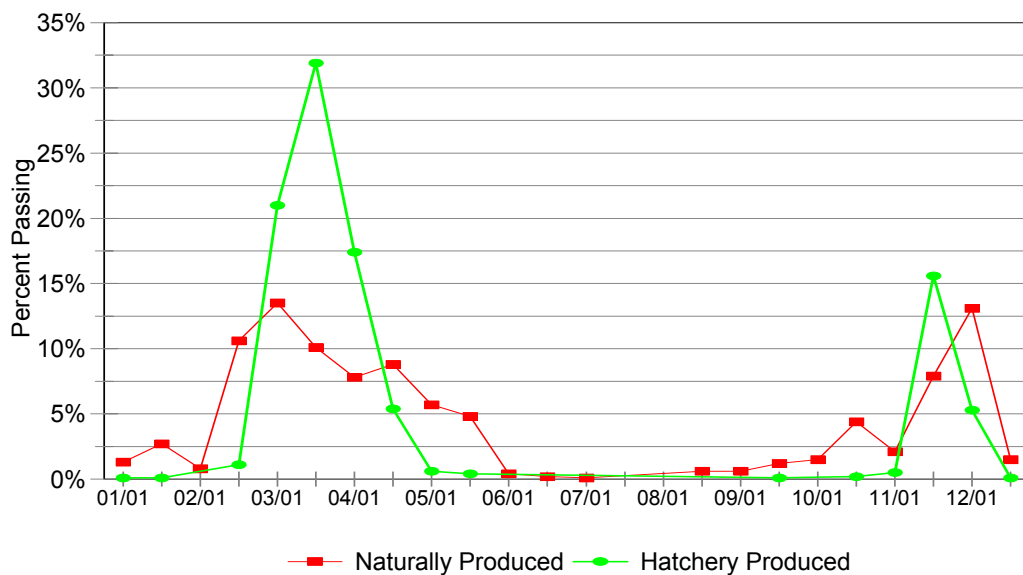
Figure 4-16.   Passage time of juvenile chinook salmon passing Willamette Falls over the period 1992-1994 (from Willis et al. 1995).

4.1.1.3.5 Ocean Stage

Willamette spring chinook salmon are "Gulf of Alaska" migrants. They migrate to the north upon ocean entry and are subject to harvest in British Columbia and SE Alaska ocean fisheries. Unlike upriver Columbia spring chinook, Willamette chinook appear to be highly vulnerable to ocean fisheries. Few adult Willamette spring chinook are caught in Oregon or California ocean fisheries (Garrison et al. 1994; Smith et al. 1985). Commercial seasons are typically not open when the adults are off the coast of Oregon, in preparation for entering the Columbia River during January through May, and few to none, depending on the brood year, are taken off the California coast (Myers et al. 1998).

4.1.1.3.6 Age At Maturity

Mattson (1962) analyzed scales taken from spring chinook salmon caught by sport fishermen in the lower Willamette River during 1946-1950, when most of the returning fish were naturally-produced and the run was comprised of a substantial number of returning adults that were 5 and 6 years old. In comparison, data from the lower Willamette River and Clackamas River fisheries in more recent years indicate that there has been a decrease in the presence of older age classes among returning adult spring chinook salmon since the late 1940s (Table 4-5). Bennett (1994) showed there was a steady decline in the percentage of older fish (i.e., age-5 and age-6) which occurred over the period 1946 to 1983. The age composition of spring chinook runs returning to the Clackamas and Willamette rivers is currently dominated by age-4 fish (Myers et al. 1998).

Table 4-5. Percentage by age class of returning spring chinook salmon caught in the lower Willamette River from 1946 to 1950 (Mattson 1948) and from 1983 to 1993, and for spring chinook salmon returning to the Clackamas River from 1977 to 1988 (from Bennett 1994).

Sample Location- Monitoring Points	Age 3	Age 4	Age 5	Age 6
Lower Willamette – 1946 to 1950	4.2%	24.2%	61.1%	10.5%
Lower Willamette – 1983 to 1993	1.7%	52.9%	44.2%	1.2%
Clackamas – 1977 to 1988	4.0%	61.4%	34.5%	1.0%

4.1.1.4 Existing Recovery Efforts

A number of corrective actions are ongoing or being implemented to increase natural production of spring chinook in the Willamette River basin. These actions should reduce the hazards to

genetic fitness for natural production of Willamette spring chinook. Collectively, these actions are focused on stopping the gradual loss of genes that produce a survival advantage in the wild. Ultimately, this can only be accomplished by increasing the fractional contribution of genetic material from naturally produced spawners to subsequent generations. Actions are described in the following paragraphs that are intended to reduce harvest rates on naturally-produced chinook, increase habitat productivity and capacity for natural production, and incorporate naturally produced fish into the hatchery broodstock. Many of these actions will also directly or indirectly benefit other listed fish species as well.

Actions to reduce harvest rates in the Columbia and lower Willamette rivers include curtailment of the winter gillnet fishery in the lower Columbia River, which favors the taking of naturally produced Willamette spring chinook (which tend to return larger and earlier than hatchery fish). The fishery was redirected to Youngs Bay by ODFW in 1995. Procedures for in-season management of the lower Willamette sport fishery were initiated by ODFW in 1995. Further, ODFW instituted regulations in 1995 to only allow the taking of marked fish in the McKenzie River.

Actions are also underway to increase natural production by restoring connectivity to habitats above dams, and by reducing losses during fish passage. The ODFW Implementation Plan for the management of Willamette spring chinook calls for re-introduction of spring chinook into the approximately 450 stream miles of habitats that were lost above dams in the Willamette River basin. Planning is underway to provide upstream and downstream passage around dams in each of the major subbasins.

Actions are also underway to increase natural productivity below dams. The USACE (1995) is preparing to retrofit Cougar Dam with temperature-control devices on the water release structures; similar actions are intended for Blue River in the future. This will improve egg-to-fry survival downstream by returning the McKenzie River (4.4 miles of South Fork, 1.2 miles of Blue River, and 23 miles of mainstem McKenzie above Leaburg Dam) to near-natural water temperatures during the critical fall and winter period of egg incubation, thereby preventing premature emergence.

New fish screens were installed in 1985 in the Leaburg Canal, and survival rates of more than 98 percent have been achieved. A new fish screen is in the final planning stages for the Walterville canal on the McKenzie River. PGE installed a prototype downstream migrant bypass system at River Mill Dam on the Clackamas River in the spring of 1995, and plans to continue efforts to improve bypass efficiency.

Some actions are underway to increase the input of naturally produced fish into hatchery brood stocks. Reintroduction of spring chinook above dams will result in returns of naturally-produced fish to hatcheries located at the base of dams. Plans have already been developed to mass mark hatchery salmon smolts at McKenzie Hatchery, such that selective harvest on hatchery fish can be implemented.

The recently formed Willamette Restoration Initiative (WRI) is developing measures to protect and restore fish and wildlife habitat and population levels in the Willamette River basin. The initiative is promoting proper floodplain management, and enhancing water quality. The WRI creates a mechanism through which residents of the basin are mounting a concerted, collaborative effort to restore watershed health. In addition, habitat protection and improved water quality in the Portland/Vancouver metropolitan areas are getting unprecedented attention from local jurisdictions. The regional government, Metro, recently adopted an aggressive stream and floodplain protection ordinance designed to protect functions and values of floodplains, and natural stream and adjacent vegetated corridors. All jurisdictions in the region must amend their land use plans and implementing ordinances to comply with the Metro ordinance within 18 months. Metro also has a green spaces acquisition program that addresses regional biodiversity, and is giving protection to significant amounts of land, some of it on the Sandy River or on tributaries to the Willamette River. The City of Portland has identified those activities, which impact salmonids, and is now using that information to reduce impacts of existing programs and to identify potential enhancement actions. The City will shortly be making significant improvements in its storm water management program, a key to reducing impacts on salmonid habitat. These measures should benefit all listed fish species in the Willamette River basin.

4.1.2 Lower Columbia River Chinook Salmon ESU

The Lower Columbia River ESU includes all native populations of chinook salmon from the mouth of the Columbia River to the crest of the Cascade Range, excluding populations above Willamette Falls. Celilo Falls, which corresponds to the edge of the drier Columbia River basin Ecosystem and historically may have presented a migrational barrier to chinook salmon at certain times of the year, is the eastern boundary for this ESU. Not included in this ESU are "stream-type" spring chinook salmon found in the Klickitat River (which are considered part of the Mid-Columbia River Spring-Run ESU) or the introduced Carson spring-chinook salmon strain. "Tule" fall chinook salmon in the Wind and Little White Salmon rivers are included in this ESU, but not introduced "upriver bright" fall-chinook salmon populations in the Wind, White Salmon, and Klickitat rivers. Available information suggests that spring chinook salmon

presently in the Clackamas and Sandy rivers are predominantly the result of introductions from the Willamette River ESU and are thus probably not representative of spring chinook salmon historically found in these two rivers (Myers et al. 1998). Designated critical habitat for this ESU includes the mainstem Willamette River below Willamette Falls (65 FR 7764).

4.1.2.1 Subpopulations and Distributions

Chinook salmon populations in the Columbia and Snake rivers appear to be separated into two genetic groups: those producing ocean-type juvenile outmigrants, and those producing stream-type outmigrants. One group consists of spring- or summer-run fish spawning in the middle Columbia basin and upstream. Fish from the Marion Forks Hatchery were determined to be related to members of this group (Schreck et al. 1986). The other group consists of populations in lower Columbia River tributaries, with both spring-run and fall-run "tule" life histories. The "tule" fall-run fish return in an advanced stage of maturation and exhibit distinct secondary maturation characteristics: darkened skin, resorbed scales, and pronounced kype. These are distinguishable from "upriver brights," which return to spawning sites above the Cascade Crest and enter freshwater at a less advanced stage of maturation. Willamette River hatchery populations form a distinct subgroup within the lower Columbia River group. Lower Columbia River ocean-type populations are genetically distinct from ocean-type chinook salmon populations east of the Cascade Range crest. However, lower Columbia River fall and spring chinook salmon appear to be closer genetically to mid- and upper Columbia River fall and summer chinook salmon, and Snake River fall chinook salmon, than they are to Willamette River spring chinook salmon. Recent releases of Rogue River fall fish at Youngs Bay and their documented straying into many tributaries in the Lower Columbia River is presently of concern regarding genetic integrity of the ESU; loss of fitness and diversity within the ESU have also been identified as important concerns (Myers et al. 1998).

The Cowlitz, Kalama, Lewis, Clackamas, and Sandy rivers presently contain both spring and fall runs, while the Big White Salmon River historically contained both spring and fall runs but presently only contains fall-run fish (Fulton 1968; WDF et al. 1993).

4.1.2.2 Population Trends

Previous assessments of stocks within this ESU have identified several stocks as being extinct, at risk of extinction, or of concern. WDF et al. (1993) considered 20 stocks within the ESU, of which only 2 were considered to be of native origin and predominantly natural production (Lewis River and East Fork Lewis River fall runs). Nehlsen et al. (1991) considered the status of

these two stocks to be healthy, whereas fourteen of the remaining non-native/natural stocks were healthy and four were depressed. The large numbers of hatchery fish in this ESU make it difficult to determine the proportion of naturally produced fish.

4.1.2.2.1 Run and Catch Sizes

There are no estimates of historic abundance of chinook salmon for the Lower Columbia ESU. Peak cannery activity for the entire Columbia River basin occurred in 1883, when 629,400 cases were packed, suggesting a total run-size of about 4.6 million chinook salmon. Natural production has been substantially reduced over the last century. Recent abundance estimates of spawners includes a 5-year geometric mean natural spawning escapement of 11,200 spring-run fish (1992-1996). The fall run includes 29,000 natural spawners and 37,000 hatchery spawners (1991-1995), but according to the accounting of PFMC (1996b), approximately 68 percent of the natural spawners are first-generation hatchery strays. Long-term trends in escapement for the fall run are mixed, with most larger stocks positive, while the spring run trends are positive or stable. Short-term trends for both runs are more negative (Myers et al. 1998).

Harvest rates on fall-run stocks are moderately high, with an average total exploitation rate of 65 percent (1982-1989 brood years) (PSC 1994). The average ocean exploitation rate for this period was 46 percent, while the freshwater harvest rate on the fall run has averaged 20 percent, ranging from 30 percent in 1991 to 2.4 percent in 1994. Harvest rates are somewhat lower for spring-run stocks, with estimates for the Lewis River averaging 24 percent ocean and 50 percent total exploitation rates in 1982-1989 (PSC 1994). Inriver fisheries harvest approximately 15 percent of the lower river hatchery stock, 29 percent of the lower river wild stock, and 58 percent of the Spring Creek hatchery stock (PFMC 1996). The average inriver exploitation rate on the stock as a whole is 29 percent (1991-1995) (Myers et al. 1998).

4.1.2.2.2 Hatchery Contribution To Natural Production

Intensive hatchery programs were initiated more than 100 years ago in this region. Nearly 4.5 billion hatchery-derived fish have been released during the last 70 years, equal to the total for all the other regions combined. The majority of these have been "tule" fall chinook salmon released into the lower Columbia River for fisheries enhancement. Because of the advanced degree of maturation that "tules" exhibit at the time of freshwater entry, the economic value of these fish is rather low; therefore, efforts have also been made to introduce Rogue River "bright" fall chinook and upper Columbia River upriver "bright" fall chinook into this region (WDF et al. 1993; Kostow 1995; Marshall et al. 1995). In addition, fall chinook salmon from the lower Columbia

River were introduced into the upper Willamette River basin beginning in the 1950s to exploit underutilized habitat.

The first hatchery on the Oregon side of the lower Columbia River was constructed on the Clackamas River in 1876. Several other hatcheries were built around the turn of the century on the Clackamas River, but none are still in operation. A variety of stocks were released from the early hatcheries, the majority being of lower Columbia River origin (Howell et al. 1985b), although some upriver stocks were propagated as well. Hatchery numbers and production increased substantially in the first half of the twentieth century. From 1913 to 1930, 319 million chinook salmon fry were released into the lower Columbia River by Washington State hatcheries alone. Oregon state and federal hatchery efforts were on a similar scale. Federal hatcheries on the Big White Salmon and Little White Salmon rivers collected 20-40 million eggs annually, and a large number of these were transferred to various Oregon and Washington state hatcheries. Over 200 million fish from outside the ESU have been released since 1930. In addition, the exchange of eggs between hatcheries in this ESU has led to the extensive genetic homogenization of hatchery stocks (Utter et al. 1989).

Cutbacks occurred in the number of hatcheries during the Great Depression and increased again after 1938. There was an interruption in hatchery operations during World War II, when production declined to one-tenth of the prewar years at Washington State hatcheries. Since the 1960s, a large number of hatchery programs in the lower Columbia River have been dedicated to mitigating for lost production (Myers et al. 1998).

Spring-run chinook salmon populations in the lower Columbia River are also all thought to be heavily influenced by hatchery programs. Approximately 1.5 and 10 million spring chinook salmon were released from Oregon and Washington hatcheries, respectively, in 1993. Populations of spring chinook salmon in the Sandy and Clackamas rivers are considered by Oregon biologists to be a component of upper Willamette River hatchery populations due to many years of inter-hatchery transfer (Kostow 1995). Dam construction and volcanic episodes have eliminated most of the historic spawning habitat for spring chinook salmon on the Washington side of the lower Columbia River (Marshall et al. 1995). Most of the spring chinook salmon spawning naturally in lower Columbia River tributaries on the Washington side are now hatchery strays (Marshall et al. 1995). All Washington populations of spring chinook salmon in the lower Columbia River are currently managed as populations of mixed origin (WDF et al. 1993).

4.1.2.2.3 Current Hatchery Fish Releases

At present, about 25 ODFW, WDFW, and USFWS hatcheries release chinook salmon in this ESU. Lower Columbia River fall chinook salmon hatchery stocks continue to make up the majority of all chinook salmon in the ESU. A majority of spawners in Oregon and Washington tributaries to the Columbia River may be hatchery strays, as well as Rogue River fall chinook salmon released in lower Columbia River streams. Straying and competition from hatchery juveniles have been identified as some of the major problems facing naturally spawning fall chinook salmon in Oregon's lower Columbia River tributaries (Kostow 1995). Oregon fall chinook salmon programs use a number of different broodstocks, including local and hatchery-origin "tule" stocks, and stocks imported from other areas. The Rogue River stock was introduced into several Columbia River tributaries to produce a south-migrating stock that would be available for harvest primarily by Oregon fishers (Kostow 1995).

4.1.2.3 Life History

4.1.2.3.1 Spawning

Fall chinook salmon are predominant in the lower Columbia River. Fall-run fish return to the river in mid-August and may spawn within a few weeks. Tule fall chinook salmon populations may have historically spawned from the mouth of the Columbia River to the Klickitat River (RKm 290). Tule fall chinook salmon begin the freshwater phase of their return migration in late August and October and the peak spawning interval does not occur until November (WDF et al. 1993).

Spring-run chinook salmon on the lower Columbia River enter freshwater in March and April, well in advance of spawning in August and September. Historically, fish migrations were synchronized with periods of high rainfall or snowmelt to provide access to upper reaches of most tributaries where fish would hold until spawning (Fulton 1968, Olsen et al. 1992, WDF et al. 1993). Dams have reduced or eliminated access to upriver spawning areas on the Cowlitz, Lewis, Clackamas, Sandy, and Big White Salmon rivers. A distinct winter-spawning run may have existed on the Sandy River (Mattson 1955), but is believed to have been extirpated (Kostow 1995).

According to Cramer et al. (1996), the upper Clackamas River spring chinook salmon spawning peak has apparently shifted from mid-August (1899) to the present day peak interval from late September to early October. This later spawning peak is consistent with upper Willamette River stocks (Myers et al. 1998).

4.1.2.3.2 Incubation

See Section 4.1.1.3.2 for general chinook salmon incubation details.

4.1.2.3.3 Juvenile Rearing and Outmigration

When environmental conditions are not conducive to subyearling emigration, ocean-type chinook salmon may remain in freshwater for their entire first year. Stream-type chinook salmon migrate during their second or, more rarely, their third spring. Under natural conditions, stream-type chinook salmon appear to be unable to smolt as subyearlings. The underlying biological bases for differences in juvenile life history appear to be both environmental and genetic. Ocean-type fish generally exhibit a faster growth rate relative to stream-type and tend to utilize estuaries and coastal areas more extensively for juvenile rearing. Stream-type chinook salmon juveniles exhibit downstream dispersal and utilize a variety of habitats during their freshwater residence. This dispersal appears to be related to resource allocation and migration to overwintering habitat.

The majority of lower Columbia River fall chinook salmon emigrate to the marine environment as ocean-type subyearlings. A portion of the brood year emigrates as yearling smolts; their migration may be a consequence of extended hatchery-rearing programs rather than natural, volitional emigration. It is also possible that modifications in the river environment may have altered the duration of freshwater residence. The natural timing of spring chinook salmon emigration is similarly obscured by hatchery releases of spring chinook salmon juveniles late in their first autumn or early in their second spring. A large proportion of smolts from the Kalama and Lewis rivers enter saltwater as subyearlings. Life-history data from the Clackamas and Sandy rivers is very limited, but transplantation records indicate that these rivers have received overwhelmingly large numbers of upper Willamette River spring chinook salmon (Myers et al. 1998) and thus may exhibit similar tendencies to the Upper Willamette ESU.

4.1.2.3.4 Ocean Stage

Marine coded wire tag (CWT) recoveries for lower Columbia River stocks tend to occur off the British Columbia and Washington coasts, with a small proportion of tags recovered from Alaska. Recoveries indicate a northerly migration route, but with little contribution to the Alaskan fishery. About 70-75 percent of other lower Columbia River hatchery fall chinook salmon turn north and are harvested in Alaska, British Columbia, and Washington (Vreeland 1989). Genetic analysis of oceanic mixed-stock harvests indicated differences in ocean distributions between "bright" and "tule" fall chinook salmon from the Columbia River. Tagging returns indicate that

"tule" fish tend to be caught in the coastal waters of Washington, whereas "upriver brights" tend to be caught in the commercial harvests of Alaska and British Columbia (Myers et al. 1998).

4.1.2.3.5 Age At Maturity

Populations in the Lower Columbia River ESU mature predominantly at ages 3 and 4, or somewhat younger than populations from the coastal, upriver, and Willamette ESUs. Adults return to tributaries in the lower Columbia River at 3 and 4 years of age for fall-run fish, and 4 to 5 years of age for spring fish. This may be related to the predominance of yearling smolts among spring-run stocks. Scale analyses indicate that the proportion of yearling migrants contributing to escapement has increased for spring-run fish over historic levels. The change is thought to be due to increased hatchery releases of yearling smolts, increased use of stream-type spring-run stocks in hatcheries, decline in Columbia River summer-run populations, or the decreased survival/abundance of naturally-reared subyearling smolts related to changing freshwater habitat or smolt passage problems (Myers et al. 1998).

4.1.2.4 Existing Recovery Efforts

Chinook salmon in this ESU are not considered to be presently in danger of extinction, but are likely to become so in the foreseeable future. Estimated overall abundance of chinook salmon in this ESU is not cause for immediate concern. However, apart from the relatively large and apparently healthy fall-run population in the Lewis River, production in this ESU appears to be predominantly hatchery-driven, with few identifiable native, naturally reproducing populations. There are no healthy native spring-run populations. Long- and short-term trends in abundance of individual populations are mostly negative, some severely so. About half of the populations comprising the Lower Columbia River ESU are very small, increasing the likelihood that risks due to genetic and demographic processes in small populations will be important. Numbers of naturally spawning spring chinook salmon are very low, and native populations in the Sandy and Clackamas rivers have been supplanted by spring-run fish from the upper Willamette River. There have been at least six documented extinctions of populations in this ESU, and it is possible that extirpation of other native populations has occurred but has been masked by the presence of naturally spawning hatchery fish (Myers et al. 1998).

Freshwater habitat is in poor condition in many basins, with problems related to forestry practices, urbanization, and agriculture. Dam construction on the Cowlitz, Lewis, White Salmon, and Sandy rivers eliminated access to a substantial portion of the spring-run spawning habitat, with a lesser impact on fall-run habitat. All basins are affected (to varying degrees) by

habitat degradation. Major habitat problems are related primarily to blockages, forest practices, urbanization in the Portland and Vancouver areas, and agriculture in floodplains and low-gradient tributaries. Substantial chinook salmon spawning habitat has been blocked, or passage substantially impaired in the Cowlitz, Lewis, Clackamas, Hood, and Sandy rivers (Myers et al. 1998).

4.1.3 Upper Willamette River Steelhead ESU

The Upper Willamette Steelhead ESU occupies the Willamette River and its tributaries, upstream from Willamette Falls, but only up to and including the Calapooia River. Three stocks of steelhead have been propagated and released in the upper Willamette River basin, but only the Willamette River winter steelhead stock reared at Marion Forks Hatchery (North Santiam River) was found by NMFS to qualify for inclusion in the ESU. The two stocks not qualifying for inclusion in the ESU are the Big Creek winter steelhead stock and the Skamania summer steelhead stock (NMFS 1999). The winter-run steelhead reproduce primarily in the Molalla, Santiam and Calapooia subbasins (Busby et al. 1996). As of 1997, the ODFW was more concerned about the fate of this ESU than any other ESU in Oregon (ODFW 1997c)

Designated critical habitat for upper Willamette River winter steelhead presently includes reaches and tributaries of the Willamette River upstream to, and including, the Calapooia River. In the Santiam River subbasin, critical habitat extends up to the base of Big Cliff and Green Peter dams (65 FR 7764).

4.1.3.1 Subpopulations and Distributions

Steelhead from the upper Willamette River are genetically distinct from those in the lower river (Busby et al. 1996). Reproductive isolation from lower river populations may have been facilitated by Willamette Falls, which is known to be a migration barrier to some anadromous salmonids. For example, winter steelhead and spring chinook salmon (*O. tshawytscha*) occurred historically above the falls, but summer steelhead, fall chinook salmon, and coho salmon did not (PGE 1994). Fish ladders were constructed at Willamette Falls circa 1885 to aid the passage of anadromous fish. The ladders have been modified and rebuilt as fish passage technology has improved, most recently in 1971 (Bennett 1987; PGE 1994). These fishways facilitated successful introduction of Skamania stock summer steelhead and early-migrating Big Creek stock winter steelhead to the upper basin. Attempts have also been made to expand the steelhead production in the upper Willamette River by stocking native Willamette steelhead in tributaries not historically used by that species (Busby et al. 1996).

Resident rainbow trout are abundant in the upper Willamette River basin, particularly in the McKenzie River and the Middle Fork Willamette River where they support popular trout fisheries. Recent genetics data from resident trout in the McKenzie and Middle Fork Willamette River basins showed that these fish have no genetic continuity with known hatchery trout (Cape Cod stock) or any Willamette River steelhead population (64 FR 14521).

Historically, spawning by upper Willamette River steelhead was concentrated in the North and Middle Santiam River basins (Fulton, 1970), and extended only up to the Calapooia River subbasin (ODFW 1995a). Steelhead are not thought to have been present historically in the McKenzie and Middle Fork Willamette river basins, but resident rainbow trout were abundant there (Busby et al. 1996). At most, they may have had a limited distribution in the McKenzie River and Middle Fork Willamette River basins (Table 4-6; ODFW 1990f).

Native steelhead primarily used tributaries on the east side of the basin; cutthroat trout predominated in streams draining the west side of the basin (Busby et al. 1996). Cutthroat and rainbow trout sympatry (i.e., co-occurrence) is rare in the Willamette system, and rainbow trout are absent where cutthroat trout are present in all Coast Range tributaries of the Willamette River basin; the winter steelhead present in Coast Range drainages may thus be naturalized rather than native (ODFW 1995a). However, steelhead likely have had some historic distribution in westside tributaries to the Willamette River (e.g., Gales Creek in the Tualatin River basin) (Busby et al. 1996).

NMFS reported in their notice of final determination that current distribution of winter-run steelhead in westside tributaries is somewhat unclear. Based on limited analysis, the recent genetics samples from steelhead in westside tributaries do not appear to reflect populations derived from this ESU (64 FR 14517). However, information provided by the state of Oregon indicates that winter-run steelhead, probably introduced stock, may be naturally reproducing in several westside tributaries (Kostow 1995; 64 FR 14517). NMFS concluded that westside tributaries to the Willamette River warranted inclusion in the Upper Willamette ESU at this time, but they expressed uncertainty regarding this conclusion (64 FR 14521).

The conclusion that steelhead were historically absent above the Calapooia River was a matter of contention initially during the chinook status review by NMFS. However, in their final determination, NMFS concluded that because; (1) rainbow trout in the McKenzie and Middle Fork Willamette were genetically distinct from steelhead; and (2) ODFW has been unable to achieve success in their attempts to establish steelhead populations upstream of the Calapooia

Table 4-6. Spawning areas of Willamette winter steelhead in the Willamette River basin, Oregon, after Willamette Project Construction (Fulton 1970).

Willamette River
  Upper mainstem
	North Santiam River
	  Mainstem
	  Lower Little N. Fork

Johnson Creek
  Midsection
	South Santiam River
	  Upper mainstem

Clackamas River
   Upper mainstem
   and tributaries
	Thomas Creek
	  Crabtree Creek
	  Wiley Creek
	  Canyon Creek

Abernathy Creek
  Mainstem
  Holcomb Creek
	Middle Santiam River
	  Mainstem
	  Quartzville Creek

Tualatin River
  Upper Gales Creek
	Calapooia River
	  Upper mainstem

Molalla River
  Mainstem
  Lower North Fork
  Butte Creek
  Abiqua Creek
  Upper Milk Creek
	McKenzie River
	  Upper Mohawk River

	Middle Fork Willamette River
	  Mainstem below Dexter Dam
	  Fall Creek
	  Winberry Creek

Yamhill River
  North Yamhill River
  Upper South Yamhill River	

River, credence could be given to the theory that, for unidentified reasons, the upper reaches of the Willamette River basin are not suitable to support steelhead populations (even though resident trout and chinook salmon have been successful there; 64 FR 14521).

Major habitat blockages resulted circa 1952 from Big Cliff Dam on the North Santiam River, circa 1967 from Green Peter Dam on the South Santiam River. These dams, along with Dexter Dam, Dorena Dam, and Cougar Dam were identified by NMFS as the upper limit of steelhead distribution for the proposed critical habitat designation for steelhead (64 FR 5750).

Present spawning and rearing distributions of native steelhead have been determined from redd counts performed by ODFW. Wevers et al. (1992b) reported that principal spawning areas in the North Santiam were in the Little North Fork, Rock Creek, and Mad Creek watersheds, and in the South Santiam were in Thomas Creek, Crabtree Creek, Wiley Creek, Canyon Creek, and Moose Creek watersheds. In the Calapooia River, most spawning occurred in the upper mainstem, North Fork, and Potts Creek (Wevers et al. 1992b). Wevers et al. (1992a) reported that principal spawning areas in the Molalla River were in the North Fork, Table Rock Fork, Milk Creek, and Copper Creek; in the Pudding River, Butte, and Abiqua creeks.

4.1.3.2 Population Trends

Determining population trends is difficult for this ESU because of its limited historic distribution, the influence of hatchery summer run fish, and the limited amount of available information. Total basin run size or escapement estimates exhibit declines for both total winter and late winter steelhead, while summer steelhead estimates exhibit an increase. However, all of these basinwide estimates have exhibited large fluctuations. Of three tributary winter steelhead stocks for which adequate adult escapement information is available to compute trends, two have been declining and one increasing over the available data series, with a range from 4.9 percent annual decline to 2.4 percent annual increase. However, none of these trends were significantly different from zero. Two of these trends (North and South Santiam River) are based on angler catch and so may not reflect trends in underlying population abundance (Busby et al. 1996). The ODFW (1997c) determined that one of the primary current wild populations, the South Santiam winter steelhead stock, was close to being unable to sustain itself.

4.1.3.2.1 Run and Catch Sizes

Native winter steelhead abundance is determined from counts of fish passing the fish ladders at Willamette Falls. Abundance of winter steelhead returning to the tributaries has been determined primarily from redd counts in April and May (ODFW 1995a). The difference in run timing between native winter steelhead and introduced Big Creek and Skamania stocks has been used as a means of estimating run size of native steelhead passing Willamette Falls. Steelhead passing the falls between February 15 and May 15 are counted as being native stock, earlier passing fish

are counted as Big Creek winter-run, and later passing fish are regarded as Skamania summer-run stock (Busby et al. 1996).

Total abundance of natural late-migrating winter steelhead ascending the Willamette Falls fish ladder has fluctuated the past several decades over a range of approximately 5,000 to 20,000 spawners (Figure 4-17). The last run exceeding 15,000 occurred in 1988. Abundance during 1991-1998 was below 5,000 fish, and the run in 1992 was the lowest in 30 years. Estimates of the proportion of hatchery fish in natural spawning escapements range from 5 to 25 percent (64 FR 14524). NMFS commented that it was possible that population sizes were never large above Willamette Falls, and that the winter steelhead in this ESU are capable of persisting at relatively low abundance (64 FR 14524).

No estimates of pre-1960s abundance are available for this ESU. Based on 1989-1993 counts at Willamette Falls, the late-run (native) winter steelhead average run size was approximately 4,200, while early-run winter and summer steelhead averaged 1,900 and 9,700 respectively. NMFS estimated from angler catch data that approximate average escapements of winter steelhead were Molalla River, 2,300; North Santiam River, 2,000; and South Santiam River, 550.
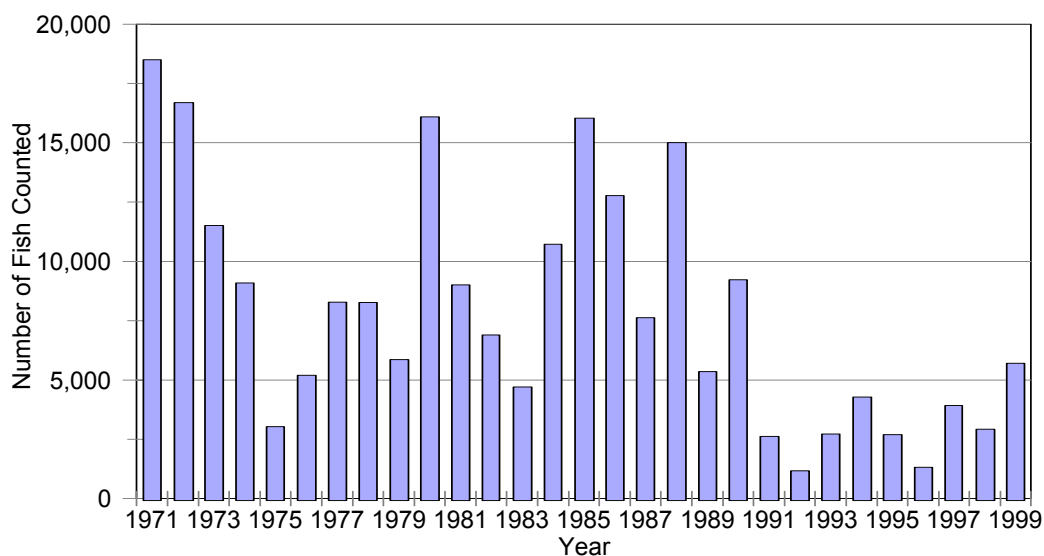
Figure 4-17.   Estimated number of native, hatchery, and wild winter steelhead passing Willamette Falls each year, 1971-1999; counts are from February 16 to May 15 each year (data from ODFW Clackamas, 1999).

The run size of native steelhead to the combined Molalla and Pudding rivers during 1976-1977 to 1988-1989 ranged from about 2,000 to 5,000 fish (Wevers et al. 1992a). Spawning is dispersed over approximately 110 miles of stream in the Molalla River and 57 miles in the Pudding River. Angling effort for adult steelhead peaked in 1987, and catch in the Molalla River averaged 1,080 winter steelhead during 1976-1986 (about half of these were Big Creek Hatchery stock) (Wevers et al. 1992a).

The historic run size of steelhead into the North Santiam River can be judged from the number of steelhead collected at the Minto fish barrier weir facility completed in 1952. Steelhead returns to Minto Dam averaged 1,000 fish during 1952-1959 (Clady 1971), and electronic counts over Elkhorn Falls on the Little North Fork Santiam averaged 120 steelhead from 1959 to 1964. Annual sport catch of adult steelhead ranged between 424 and 2,188 fish in the North Santiam River during 1977-1988 (Wevers et al. 1992b).

On the South Santiam River, counts of steelhead over Foster Dam (completed in 1966) ranged from 1,100 to 4,250 during 1967 to 1972. Fish passage problems resulted in rapid declines of steelhead past Foster and Green Peter dams, and numbers declined to 200 to 1,497 during 1980-1990 over Foster Dam, and only 0 to 78 fish over Green Peter Dam. Annual sport catch of adult steelhead ranged between 111 and 1,181 fish in the South Santiam River during 1977-1988 (Wevers et al. 1992b).

The run size of native steelhead into the Calapooia River has not been estimated, but annual sport catch of adult steelhead ranged from 0 to 122 during 1977-1988 (Wevers et al. 1992b).

4.1.3.2.2 Hatchery Contribution To Natural Production

The major present threat to the genetic integrity of steelhead in this ESU comes from past and present hatchery practices. While there is some separation in run timing between hatchery and wild winter steelhead, there appears to be sufficient overlap in spawn timing for some genetic introgression from non-local hatchery stocks to occur. An additional effect of hatchery production may be directional selection within the natural stocks resulting both from competition with hatchery fish (both winter and summer) and selective fishing pressure that eliminates individuals with early run-timing from the natural stocks (Busby et al. 1996).

The main production of native (late-run) winter steelhead is in the North Santiam River, where estimates of the hatchery proportion of naturally spawning fish range from 14 to 54 percent (ODFW 1995b, 1995c). The Marion Forks Hatchery on the North Santiam River produces the

majority of hatchery winter steelhead in the Willamette River basin (ODFW 1990a). There is strong concern about the pervasive opportunity for genetic introgression from hatchery stocks and the potential for ecological interactions between introduced stocks and native stocks. There is widespread production of hatchery steelhead within the range of this ESU, predominantly of non-native summer and early-run winter steelhead. Most of the largest hatcheries are located in the Santiam and McKenzie subbasins. Recorded hatchery releases of summer steelhead between 1980 and 1994 have numbered more than five million in the Santiam River system, two million in the McKenzie River system, and nearly two million in the Willamette River. More than two million hatchery-origin winter steelhead have been released in the Santiam system, and approximately one and ten percent of that number have been released in the McKenzie and Willamette rivers, respectively (Busby et al. 1996). It is unknown to what degree interaction has occurred between hatchery and natural stocks within the ESU overall, in part because the quality of available data is generally low.

NMFS identified three hatchery stocks associated with the Upper Willamette River ESU (NMFS 1999c), and concluded that the North Santiam River hatchery stock (ODFW Stock 21 at Marion Forks Hatchery) should be considered part of the ESU. Marion Forks Hatchery began operation in 1951 by taking their eggs from fish that returned naturally to Minto Dam, and "run-timing and spawning period have remained relatively unchanged since 1951" (Chilcote 1998). The other two hatchery stocks, Big Creek (ODFW Stock 13) and Skamania, were introduced from outside the Willamette River basin, and should not be considered part of the ESU (64 FR 14521).

Although the winter steelhead stock reared at Marion Forks Hatchery was included in the ESU, NMFS concluded the stock likely had been genetically altered by hatchery practices, and was not essential to recovery of the ESU (NMFS 1999). NMFS (1999a) reported that electrophoretic data from 41 allozyme loci showed no genetic distance between Marion Forks Hatchery winter steelhead and wild steelhead from the North Fork Molalla River, and little genetic distance between this hatchery stock and wild winter steelhead in the North Santiam River.

Chilcote (1998) found evidence that competition between native and introduced steelhead was having a deleterious effect on recruits produced per spawner. He estimated that competition from introduced summer steelhead had caused a 27 percent reduction in productivity of the native Clackamas winter steelhead. Chilcote (1998) concluded that a similar reduction in productivity may have occurred in other Willamette subbasins where introduced stocks were commonly released, such as the Molalla, North Santiam, and South Santiam rivers.

4.1.3.2.3 Current Hatchery Fish Releases

All stocking of winter steelhead ceased in the Santiam River subbasin after 1998, and in the Molalla River after 1997. Stocking of steelhead has never occurred in the Calapooia River. Stocking of Skamania summer steelhead has been discontinued in the Molalla River, but continues in the North and South Santiam rivers. Summer steelhead collected at the Minto Facility weir are returned downstream to the recreational fishery, to avoid interbreeding with native steelhead. However, hatchery fish have been widespread and have escaped to spawn naturally throughout the ESU during the past two decades. Both summer steelhead and early-run winter steelhead have been introduced into the basin and spawn naturally in substantial numbers.

Over 175,000 winter steelhead are released annually into the region occupied by this ESU. Although most releases are from hatchery stocks derived from native winter steelhead originating in the Santiam River system, substantial numbers of Gnat Creek (Big Creek-stock) winter steelhead from the lower Columbia River are also introduced into the area every year. The latter transplants have succeeded in establishing naturally reproducing populations of Big Creek-stock steelhead in the upper Willamette River basin. Natural production of summer steelhead appears to be low (2.5% of total run in 1981), and the population is largely maintained by releases of hatchery fish (Busby et al. 1996).

4.1.3.3 Life History

The native steelhead of this basin are late-migrating winter steelhead, entering fresh water primarily in March and April (Howell et al. 1985b), whereas most other populations of west coast winter steelhead enter fresh water beginning in November or December. Production of winter steelhead does not occur in the mainstem Willamette River; all production occurs in tributaries (ODFW 1990b).

4.1.3.3.1 Spawning

Some data are available to characterize the return timing of upper Willamette steelhead, first as they pass through the fish ladder at Willamette Falls, and then as they enter sport fisheries in the tributaries. Passage over Willamette Falls begins in early February, peaks throughout the month of March, and ceases in late May (Figure 4-18). It can be seen in Figure 4-18 that passage of introduced Big Creek stock overlaps passage of the early portion of the native run, but there is relatively little overlap with the Skamania summer run that begins in late May. Angler catch of steelhead in the Molalla River also peaks in March (Figure 4-19) (Wevers et al. 1992a). Peak
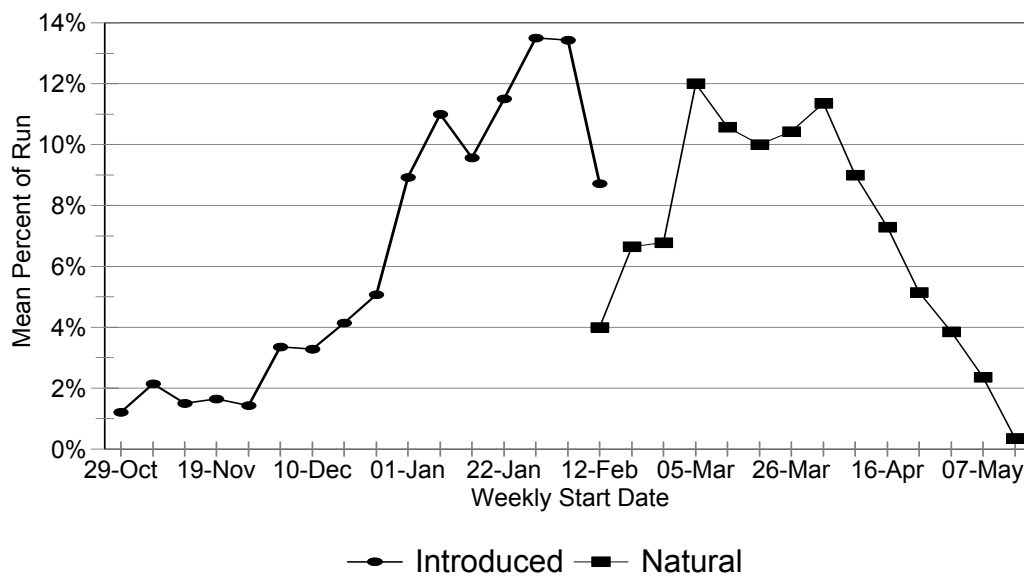
Figure 4-18. Percentage of the annual steelhead run that crossed Willamette Falls each week, averaged for 1984-1998. Introduced and natural runs are distinguished by February 15 as a cutoff date, and percentages are calculated relative to each run's total size (data from ODFW, Clackamas 1999).
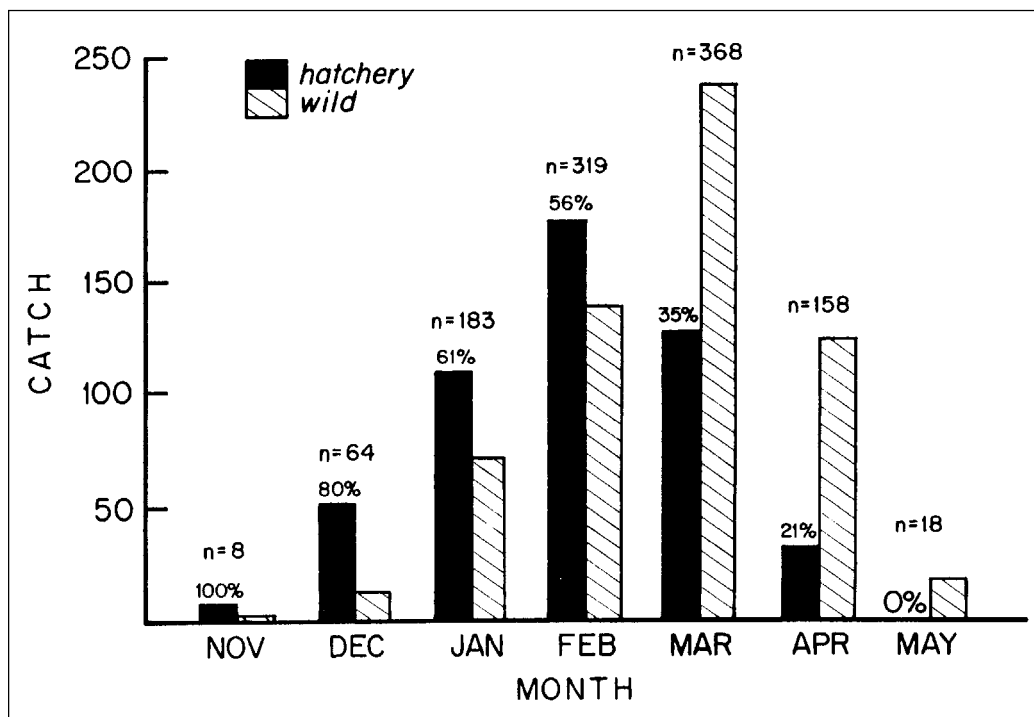
Figure 4-19. Average monthly winter steelhead catch and percentage composed by non-native hatchery fish in the Molalla River, Oregon 1979-1986 (from Wevers et al. 1992a).

returns to the Minto collection facility on the North Santiam River occur during April (Wevers et al. 1992b). On the South Santiam River, counts over Foster Dam peak in mid-April (Wevers et al. 1992b).

Spawning activity peaks in April in tributaries to the west side, and in May in tributaries draining the Cascade range to the east (ODFW 1990a; Wevers et al. 1992a). Steelhead in the Upper Willamette ESU generally spawn once or twice, and will infrequently spawn more than that; a few fish may spawn three times based on patterns found in the Lower Columbia ESU. Repeat spawners are predominantly female and generally account for less than 10 percent of the total run size (Busby et al. 1996). Spawning occurs primarily high in the upper tributaries (ODFW 1990a).

4.1.3.3.2 Incubation

Incubation rates vary with water temperature with eggs hatching anywhere between 18 and 101 days (Emmett et al. 1991); eggs will hatch in 50 days when water temperature is 10.0°C (Wydoski and Whitney 1979). Fry emergence of Willamette winter steelhead is thought to occur predominantly in June; Big Creek steelhead emerge mainly in March and April (ODFW 1990a).

4.1.3.3.3 Juvenile Rearing and Outmigration

Data on juvenile rearing distributions are limited, but indicate that juvenile steelhead reside both within their native tributaries and in the mainstem Willamette River. Seining studies conducted by ODFW between 1991 and 1998 have found that juvenile steelhead in the mainstem are mostly distributed during the late summer between RM 133 near Corvallis and the mouth of the McKenzie River. Snorkel surveys conducted in 1998 in the Santiam River system found juvenile steelhead below Salmon Falls on the Little North Fork Santiam River, below the Little North Fork on the North Santiam River, in Crabtree and Thomas creeks (tributaries to lower South Santiam River), and in the South Santiam River above Foster Lake. Snorkel surveys conducted the same year also found juvenile steelhead in the Calapooia, Molalla, and Pudding River basins (ODFW 1998 data).

Emigration of native steelhead smolts occurs from late March to late May, generally after their second winter in freshwater (Wevers et al. 1992a, 1992b). About 88 percent of naturally produced adults from the North Santiam River during 1957-1959 had smolted at age 2; 12 percent at age 3 (Wevers et al. 1992b). Smolt migration of Willamette winter steelhead past Willamette Falls begins in early April and extends through early June (Howell et al. 1985b), with peak migration occurring in early to mid-May. Mean lengths of naturally produced smolts

sampled weekly at Willamette Falls (1976-1978) ranged from 170 mm to 220 mm. Larger smolts migrated significantly earlier than the smaller smolts (Buchanan et al. 1979).

Knutsen and Ward (1991) radio tagged and tracked steelhead smolts through Willamette Harbor in the Portland vicinity. They found median migration rates during 1989 and 1990 were 11.1 to 10.3 miles per day. Steelhead smolts were generally further from shore and in shallower water than yearling chinook smolts. Both steelhead and chinook smolts migrated more often through Multnomah Channel than out the mouth of the Willamette River. Even yearling chinook, which migrated slower than steelhead, migrated through the harbor area within a few days.

4.1.3.3.4 Ocean Stage

Most, if not all, upper Willamette steelhead spend 2 years (2-ocean) in the ocean before entering fresh water to spawn (Busby et al. 1996).

Cramer et al. (1997) reviewed available data on the variation in smolt-to-adult survival of lower Columbia steelhead, and concluded that ocean survival of steelhead dropped to low levels across the West Coast in the early 1990s. Of the full suite of possible causes for sharp declines in steelhead escapement during the 1990s, the decline in ocean survival was concluded to be the factor that correlated best with the decline in steelhead escapement. Kalama River summer steelhead and Eagle Creek (Clackamas basin) winter steelhead smolt-to-adult survival rates of hatchery fish showed a high degree of covariation over the last 12 broods, during which survival varied more than ten-fold between smolt years. Smolt-to-adult survivals were near record lows in 1992 and 1993 for steelhead in many West Coast streams. Cramer et al. (1997) deduced that the net result of these declines in survival in the 1990s was that returns of adult winter steelhead in 1994-1997 would be one-third to one-eight of what they were in 1992, even if the number of smolts produced in those years was equal.

4.1.3.3.5 Age At Maturity

Most coastal steelhead in Washington and Oregon have a modal total age at maturity of 4 years (2 freshwater/2 ocean); some fish are five years old (Busby et al. 1996). About 65 percent of adults in the Upper Willamette ESU are 2-ocean and 35 percent are 3-ocean in the Molalla River (Wevers et al. 1992a). Scale samples from the 1957-1959 broods on the North Santiam River indicated all had spent 2 years in the ocean. On the South Santiam, scales from adults produced by the 1977 and 1978 smolt years showed that 92 percent were ocean age 2, and the remainder age 3 (Wevers et al. 1992b).

4.1.3.4 Existing Recovery Efforts

Native winter steelhead within this ESU have been declining on average since 1971, and have exhibited large fluctuations in abundance. There are a large number of major habitat constraints on winter steelhead production in the basin, including sedimentation, flow, water quality, and migration barriers (ODFW 1990a). However, the ESU does not appear to be presently in danger of extinction. Its future risk is less clear; small numbers and a declining trend in the native stock, coupled with other risk factors indicate a likelihood of the ESU becoming endangered. While historical information regarding this ESU is lacking, geographic range and historical abundance are believed to have been relatively small compared to other ESUs, and current production probably represents a larger proportion of historical production than is the case in other Columbia River Basin ESUs (Busby et al. 1996). Nehlsen et al. (1991) identified one stock (Calapooia River) as of special concern.

Chilcote (1998) developed indices of wild steelhead spawner abundance in five subbasins of the upper Willamette and found that three (Molalla, Upper South Santiam, and Calapooia) met criteria for an endangered classification (>20 percent chance of extinction in 20 years), while the other two (lower South Santiam and North Santiam) met criteria for sensitive classification (>5 percent chance of extinction in 100 years). However, the reliability of these findings is low because of assumptions used to complete the analysis (Chilcote 1998). Most abundance indices used by Chilcote were based on estimates of numbers of spawners per stream mile (Table 4-7), which were extrapolated from spawning surveys in index areas. Chilcote (1998) used a Ricker stock-recruitment curve to estimate probabilities of extinction. He found no significant relation for run size data in the Molalla, and the regression accounted for only 22-42 percent of variation in recruits per spawner in the other four Willamette populations with data. Chilcote noted that there were a number of problems confounding the analysis, including particularly the lowered fitness of natural spawners from hatchery origin. He concluded that wild fish considered alone are probably healthier than they appear when data include a mixture of hatchery and wild fish.

Wild steelhead catch-and-release regulations were implemented for the entire Willamette River basin in 1994 (ODFW 1995a). Together with the listing, it is presently illegal to kill native winter steelhead in the Willamette system. Reduction in sport fishing mortality should help maintain if not increase escapement levels. Cramer et al. (1997) estimated that for streams of the lower Columbia basin, the greatest mortality to steelhead from sport angling was for juvenile steelhead from trout fisheries. Mortality was highest in areas where catchable trout were stocked and angler access was high. Haxton (1985) estimated that angler effort in the Molalla River was ten times greater in stocked reaches than in unstocked reaches located further upstream. Cramer

Table 4-7   Estimated indices of spawner abundance for five winter steelhead populations in the
Willamette River basin, Oregon above Willamette Falls; spawner abundance expressed
as total fish for the upper South Santiam population and spawners per stream mile for all
other populations (data from Chilcote 1998).

| | Molalla | | North Santiam | | Lower South Santiam | | Upper South Santiam Total Fish | | Calapooia |
| | Number Per Mile | | Number Per Mile | | Number Per Mile | | Total Fish | | Number Per Mile |
Year	Wild[1]	Hatchery[2]	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
1971	44.2	37.6	55.1	11.3	43.8	0.0	Unknown	Unknown	23.2
1972	41.2	35.1	52.1	10.7	41.6	0.0	Unknown	Unknown	21.6
1973	32.8	28.0	43.7	9.0	35.2	0.0	755	0	16.9
1974	28.9	24.6	39.8	8.1	32.3	0.0	695	0	14.7
1975	19.0	16.2	30.0	6.1	24.9	0.0	354	0	9.1
1976	22.5	19.2	33.5	6.9	27.5	0.0	302	0	11.1
1977	27.5	23.5	38.5	7.9	31.3	0.0	503	0	13.9
1978	27.5	23.5	38.5	7.9	31.3	0.0	488	0	13.9
1979	23.6	20.1	34.6	7.1	28.3	0.0	149	0	11.7
1980	41.1	35.0	51.2	10.5	40.9	0.0	515	0	13.0
1981	33.6	28.6	39.6	8.1	32.2	0.0	317	0	9.0
1982	29.5	25.1	36.2	7.4	17.4	12.2	234	165	21.8
1983	20.2	17.2	41.9	8.6	16.8	8.3	134	66	17.6
1984	28.5	24.3	41.9	8.6	11.5	22.7	504	993	16.1
1985	39.8	33.9	42.4	8.7	17.2	30.4	355	629	25.8
1986	34.9	29.7	69.8	14.3	14.8	22.0	326	485	18.0
1987	27.5	23.4	45.8	9.4	15.5	18.3	214	253	22.3
1988	35.0	29.9	45.3	9.3	19.8	12.8	656	423	20.4
1989	25.8	21.9	24.5	5.0	17.1	4.8	222	62	8.5
1990	29.1	24.8	47.4	9.7	313.0	1.2	272	10	14.8
1991	18.6	15.8	34.5	7.1	33.7	0.0	139	0	14.3
1992	25.1	7.9	24.9	5.1	29.5	0.0	361	0	5.5
1993	7.5	2.4	27.6	5.7	16.0	0.0	256	0	1.8
1994	30.3	9.6	26.2	5.4	28.0	0.0	234	0	7.5
1995	11.9	3.8	17.6	3.6	24.5	0.0	297	0	5.1
1996	18.6	5.9	29.6	6.1	24.6	0.0	131	0	8.9
1997	7.8	2.5	22.2	4.5	9.8	0.0	311	0	11.7

[1] Estimated to be of natural origin.

[2] Estimated to be of hatchery origin.

et al. (1997) estimated that angling mortality of juvenile steelhead during the 1980s was often in the range of 35 to 60 percent in popular Oregon streams of the lower Columbia basin such as the Clackamas and Sandy rivers. Angler access is high and stocking of catchable trout was extensive in the Molalla, Santiam, and Calapooia river basins during the 1980s and early 1990s, so angling mortality of juvenile steelhead was probably similar to the ranges estimated by Cramer et al. (1997) for popular lower Columbia streams. These high mortality levels should have been sharply reduced in recent years as ODFW ceased stocking catchable trout in anadromous streams, and trout angling was restricted to catch and release in reaches where native steelhead have access.

The ODFW (1998a) has developed a proposal regarding the need for specific mainstem Willamette River flows intended to benefit primarily juvenile winter steelhead, but also other anadromous and resident fish stocks. The objective of the proposal was to recommend flows that will increase survival during critical life history stages, including of downstream-migrating smolts and upstream-migrating adults, and provide for better passage conditions at Willamette Falls and the associated hydroelectric facilities that are located there. Specific minimum flows recommended for the Willamette River at Salem were: 16,000 cfs between April 15 and April 30; 11,500 cfs between May 1 and May 15; and 8,500 cfs between May 16 and May 31.

Steps have been taken by the USACE, USFWS, ODFW, and NMFS to relocate at least 90 percent of a Caspian tern colony away from areas in the lower Columbia where their primary food is juvenile salmonids, especially steelhead.

The state of Washington is developing a statewide strategy to protect and restore wild steelhead and other salmon and trout species. In May of 1997, Governor Gary Locke and other state officials signed a Memorandum of Agreement creating the Joint Natural Resources Cabinet. This body is comprised of state agency directors or their equivalents from a wide variety of agencies whose activities and constituents influence Washington's natural resources. The goal of the Joint Natural Resources Cabinet is to restore salmon, steelhead, and trout populations by improving those habitats on which the fish rely. The Joint Natural Resources Cabinet's recent activities have included the development of the Lower Columbia Steelhead Conservation Initiative, which is intended to comprehensively address protection and recovery of steelhead in the lower Columbia River area.

With respect to federal lands, the National Forest Plan has reportedly reduced habitat degradation within this ESU. Approximately 28 percent of land area in the Willamette basin is National Forest Land (PNERC 1998).

4.1.4 Lower Columbia River Steelhead ESU

The Lower Columbia River Steelhead ESU occupies tributaries to the Columbia River inclusive of an area between the Cowlitz and Wind rivers in Washington and the Willamette and Hood rivers in Oregon. Steelhead-bearing rivers within this region drain the Cascade Mountains from Mount Rainier to Mount Hood. The ESU is composed of winter (enter fresh water between November and April) and summer (enter fresh water between May and October) strains that appear to be genetically similar on average, although there may be differences between summer and winter steelhead in any given drainage. Non-anadromous rainbow trout co-occur with the anadromous steelhead form in lower Columbia River tributaries (Busby et al. 1996). Designated critical habitat for this ESU includes the mainstem Willamette River below Willamette Falls (65 FR 7764).

WDFW's Genetic Conservation Management Units (GCMUs) for steelhead are intended to be comparable to ESUs and consider many of the same factors (genetics, environment, life history); ODFW's Gene Conservation Groups (GCGs) are based primarily on genetics. In contrast to ESUs, which may transcend political boundaries, both GCMUs and GCGs consider only populations within their respective state boundaries. The Oregon part of the Lower Columbia River and Southwest Washington ESUs are similar to one of Oregon's GCGs. WDFW has identified a GCMU for the lower Columbia River that is consistent with the NMFS ESU (Busby et al. 1996).

4.1.4.1 Subpopulations and Distributions

Steelhead populations in the Lower Columbia River ESU are genetically distinct from steelhead from the inland Columbia River basin, from the upper Willamette River, and from coastal streams in Oregon and Washington. Steelhead in the upper Willamette River basin above Willamette Falls, and in the Little and Big White Salmon rivers, Washington are consequently not part of the ESU. There is a particularly strong difference between coastal and inland steelhead in the vicinity of the Cascade Crest, but the exact boundaries are unclear (Busby et al. 1996).

4.1.4.2 Population Trends

While the majority of stocks in the ESU for which data exist have been declining in the recent past, a few have been increasing strongly. However, the strongest upward trends are for either

non-native stocks (Lower Willamette River and Clackamas River summer steelhead) or stocks that are recovering from major habitat disruption and are still at low abundance (mainstem and North Fork Toutle River). The data series for most stocks are relatively short, so the preponderance of downward trends may reflect the general coastwide decline in steelhead in recent years (Busby et al. 1996).

Nehlsen et al. (1991) identified 19 stocks in the Lower Columbia ESU to be at risk or of concern. WDF et al. (1993) considered 23 stocks within the ESU, of which 19 were considered to be of native origin and predominantly natural production. The status of these 19 stocks was 2 healthy, 10 depressed, and 7 unknown. All four of the remaining (not native/natural or unknown origin) stocks were classified as depressed (Busby et al. 1996).

4.1.4.2.1 Run and Catch Sizes

No estimates of historical (pre-1960s) abundance specific to this ESU are available. Total run size for the major stocks in the lower Columbia River (below Bonneville Dam, including the Upper Willamette ESU) for the early 1980s were estimated to be approximately 150,000 winter steelhead and 80,000 summer steelhead. Recent 5-year average natural escapements for streams with adequate data range from less than 100 to 1,100. Total recent (5-year average) run size for major streams in this ESU was greater than 16,000, but this total includes only the few basins for which estimates are available. The Clackamas River is estimated to have winter and summer steelhead run sizes that are 1,300 and 3,500 fish, respectively (Busby et al. 1996).

Of 18 stocks for which adequate adult escapement information are available, 11 are thought to have been declining and 7 increasing during the late 1970s to the mid-1980s. Most of the Oregon trends are based on angler catch and may not reflect trends in underlying population abundance. The trends for lower Willamette winter and summer steelhead runs are positive, with small increases of approximately 2.5 and 9.3 percent per year, respectively. The trend for winter steelhead in the Clackamas River is slightly negative (-0.4 percent per year); for summer steelhead, the trend is positive (10.8 percent per year) (Busby et al. 1996).

4.1.4.2.2 Hatchery Contribution To Natural Production

Hatchery fish are widespread and escape to spawn naturally throughout the Lower Columbia ESU region. The major present threat to genetic integrity for steelhead in this ESU comes from past and present hatchery practices. Most of the hatchery stocks originated primarily from stocks within the ESU, but many are not native to local river basins. Some Washington stocks (notably

Kalama River winter and summer steelhead) appear to have substantial hatchery contribution to wild spawning, and Nehlsen et al. (1991) identified several stocks to be of special concern due to hatchery influence. ODFW estimates of hatchery composition indicate a range from about 30 percent (Sandy River and Tanner Creek winter steelhead) to 80 percent (Hood River summer steelhead) hatchery fish in spawning escapements. Approximately 75 percent of the total lower Columbia run (summer and winter steelhead combined) in the 1980s was estimated to be of hatchery origin. The NMFS estimated that roughly 70 percent of the Clackamas River winter steelhead run is of hatchery origin (Busby et al. 1996). In contrast, the ODFW (1997c) estimated that hatchery fish accounted for 26 percent of the Clackamas population above North Fork Dam. Of hatchery steelhead that have been released between 1980 and 1994, more than eighty percent of summer steelhead, and between twenty and forty percent of winter steelhead, are believed to be non-native in origin (Busby et al. 1996).

The degree of interaction between hatchery and natural stocks within the ESU is not well known. There is some evidence of relatively little overlap in spawning between natural and hatchery stocks of winter steelhead throughout the ESU, and strong overlap in spawning between hatchery and natural summer steelhead in Washington tributaries. No information is available regarding potential spawning separation between hatchery and natural fish in Oregon tributaries to the lower Columbia River (Busby et al. 1996).

In addition to numerous smaller-scale supplementation and hatchery operations, there are six major hatcheries that directly influence the Lower Columbia River ESU area: the Cowlitz, Gobar Pond, Clackamas, Eagle Creek, Vancouver, and Skamania facilities. Other hatcheries from the Southwest Washington ESU also influence lower Columbia runs, including the Big Creek and Cowlitz facilities. Big Creek and Cowlitz River winter steelhead stocks dominate the production of hatchery winter steelhead in the lower Columbia River basin. The Big Creek stock is produced on the Oregon side, and the Cowlitz stock on the Washington side (CBFWA 1990). The Big Creek stock was developed in the 1960s from the earliest maturing steelhead native to Big Creek (Howell et al. 1985b). The initial source for the Cowlitz Hatchery stock was a 1:1 mix of Chambers Creek and native Cowlitz River fish (Crawford 1979). The Big Creek and Cowlitz Hatcheries produce about 700,000 and 650,000 smolts per year, respectively, that are released into most major river basins tributary to the Columbia River below Bonneville Dam (Howell et al. 1985b). Cowlitz stock steelhead eggs have been used in hatchery programs of other states, including California (Howell et al. 1985b; CDFG 1994). Big Creek winter steelhead have established naturally reproducing populations in the upper Willamette River basin (Howell et al. 1985b). More than eight million smolts were released in the Clackamas River alone between 1980 and 1994 (Busby et al. 1996).

Given the relatively low natural run sizes to individual streams, the preponderance of negative trends in abundance, and the apparent substantial contribution of hatchery fish to production, there is concern that the majority of natural steelhead populations in this ESU (both winter and summer) may not be self-sustaining (Busby et al. 1996).

4.1.4.2.3 Current Hatchery Fish Releases

More than 2 million winter steelhead and over 1 million summer steelhead smolts are released each year within the basins occupied by the Lower Columbia River ESU. The primary winter steelhead stocks used in hatchery programs in the lower Columbia River are from Eagle Creek and Gnat Creek Hatcheries in Oregon, and Beaver Creek (Elochoman River/Chambers Creek origin) and the Cowlitz River in Washington (Howell et al. 1985b). Chambers Creek winter steelhead from Puget Sound are also an important component of lower Columbia River hatchery management (Howell et al. 1985b). In some cases, the influence of hatchery steelhead is pronounced: Cowlitz River wild winter steelhead are almost all the progeny of feral Cowlitz Hatchery steelhead (WDF et al. 1993). Skamania-stock summer steelhead are used extensively in both Washington and Oregon tributaries of the lower Columbia River (Busby et al. 1996).

4.1.4.3 Life History

Life history attributes for steelhead within this ESU appear to be similar to those of other west coast steelhead and are described below.

4.1.4.3.1 Spawning

Variations in migration timing exist between summer and winter steelhead populations, but there is considerable overlap. Some river basins have both summer and winter steelhead; others have only one type. It appears that the summer, or stream-maturing, steelhead occur where habitat is not fully utilized by winter steelhead. Summer steelhead usually spawn farther upstream than winter steelhead. In rivers where the two types co-occur, they are often separated by a seasonal hydrologic barrier, such as a waterfall. Streams near the coast are dominated by winter steelhead (Busby et al. 1996).

Freshwater entry occurs between March and October, depending on the run. Adults enter the lower Willamette and Clackamas rivers in February and March. Spawning begins in April, and peak activity occurs in May and June. Steelhead in the Lower Columbia River ESU may spawn

once or twice, and only infrequently more than that; a few fish may spawn three, and in rare instances four times. Repeat spawners are predominantly female and generally account for less than 10 percent of the total run size (Busby et al. 1996).

4.1.4.3.2 Incubation

See Section 4.1.3.3.2.

4.1.4.3.3 Juvenile Rearing and Outmigration

The majority of smolts are 2 years of age. Hatchery smolts are more frequently one year old, and this difference is often used to distinguish hatchery from naturally-produced individuals.

4.1.4.3.4 Ocean Stage

Most lower Columbia steelhead spend 2 years (2-ocean) in the ocean before entering fresh water to spawn. Populations in Oregon and California have higher frequencies of age-1-ocean steelhead than populations to the north, but age-2-ocean steelhead generally remains dominant, particularly in the Willamette River system (Busby et al. 1996).

4.1.4.3.5 Age At Maturity

Most coastal steelhead in Washington and Oregon have a modal total age at maturity of 4 years (2 freshwater/2 ocean); some fish are five years old. Summer steelhead in the Columbia River basin enter fresh water up to a year prior to spawning, and that year is generally not accounted for in the saltwater age designation; they can have a total age of 5 years at first spawning (Busby et al. 1996).

4.1.4.4 Existing Recovery Efforts

Significant habitat blockages resulted from dams on the Sandy River and minor blockages (such as impassable culverts) are likely throughout the region. Habitat problems for most stocks in this ESU are similar to those in adjacent coastal ESUs. Clear-cut logging has been extensive throughout most watersheds in this area, and urbanization is a substantial concern in the Portland and Vancouver areas. Because of their limited distribution in upper tributaries, summer steelhead appear to be more at risk from habitat degradation than are winter steelhead (Busby et al. 1996).

The Lower Columbia River Steelhead ESU does not appear to be in danger of extinction presently, but it is likely to become endangered in the foreseeable future. However, there is some doubt whether native steelhead still exist in this region. The majority of stocks for which we have data within this ESU have been declining in the recent past, but some have been increasing strongly. However, the strongest upward trends are those of either non-native stocks (lower Willamette River and Clackamas River summer steelhead) or stocks that are recovering from major habitat disruption and are still at low abundance (mainstem and North Fork Toutle River). The data series for most stocks are quite short, so the preponderance of downward trends may reflect the general coastwide decline in steelhead in recent years. There is strong concern about the pervasive opportunity for genetic introgression from hatchery stocks, and for the status of summer steelhead in this ESU. There is widespread production of hatchery steelhead within this ESU, and the average composition of several stocks is more than 50 percent hatchery fish in the natural escapement. Concerns about hatchery influence are especially strong for summer steelhead and Oregon winter steelhead stocks, where there appears to be substantial overlap in spawning between hatchery and natural fish (Busby et al. 1996).

4.1.5 Lower Columbia River/Southwest Washington Coho Salmon ESU

Coho return to most streams tributary to the Columbia River downstream from Bonneville Dam. The Lower Columbia River/Southwest Washington Coho Salmon ESU has been strongly influenced by hatchery production, and it is difficult to determine its status and population trends from available information. Because this ESU has not yet been listed, critical habitat has not been designated.

4.1.5.1 Subpopulations and Distributions

Genetic data indicate that coho salmon from the north Oregon coast/Columbia River are generally reproductively isolated from other west coast coho salmon stocks, with restricted gene flow between areas (Weitkamp et al. 1995). Electrophoretic studies with allozymes have shown that coho from the Columbia River are genetically distinct from those in coastal basins. Recently developed techniques for DNA typing have been applied to native Clackamas coho, and have indicated they are quite different from coho in the Sandy River and Columbia River hatcheries. Comparisons of inherited traits, such as ocean distribution, run timing, and egg size also indicate that native Clackamas coho are unique from other Columbia River stocks (Cramer and Cramer 1994). However, there is insufficient evidence regarding the history of hatchery influence on late-run Clackamas River coho salmon to conclude whether the Clackamas population represents the historical lower Columbia River/Southwest Washington ESU (Weitkamp et al. 1995).

4.1.5.2 Population Trends

Surveys indicate that natural spawning of coho salmon in this region declined precipitously in the early 1970s and has remained at extremely low levels. Production of the native population appears to be depressed because of a variety of factors, and the population is likely to remain stable but vulnerable to overharvest under current harvest rates (Johnson et al. 1991; Cramer and Cramer 1994). Nehlsen et al. (1991) classified Hood River, Sandy River, and all other lower Columbia River tributary stocks as being at high risk of extinction, except the Clackamas River stock, which was classified as at moderate risk of extinction. The ODFW recently concluded that, with the exception of the Clackamas and Sandy River runs, wild coho populations downstream of Willamette Falls are most likely extirpated, because of high harvest rates, poor ocean conditions, habitat degradation, and other factors. The Clackamas population is the only one presently considered to not be endangered (Chilcote 1999).

4.1.5.2.1 Run and Catch Sizes

The last naturally-reproducing population of coho of any consequence during the past decade has been in the Clackamas River above North Fork Dam. Run timing into the Clackamas River is bimodal and the two peaks correspond to different ancestries. Native Clackamas coho are termed "late run" because they begin returning to the river in October and spawn in February and March. During the period 1962-1979, many thousands of non-native coho were introduced into the Clackamas River. Although hatchery liberations above North Fork Dam were terminated, these fish persist as a naturally-spawning, self-sustaining population. These coho are termed "early run" because they begin returning to the Clackamas in August and spawn in November. The introduction of the early-run coho, coupled with over-harvest of the October portion of the run, has drastically altered the coho return pattern at North Fork Dam since the early 1960s (Figure 4-20). The shift to a later time of passage at North Fork Dam for native coho corresponded to the increase in the gill net effort in late October and November (Cramer and Cramer 1994).

Abundance of the native run of coho salmon in the Clackamas River has been measured since 1950 by adult passage at River Mill (1950-1957) and North Fork (1958-present) dams total run size (native and hatchery) has ranged from 416 (1950) to 4,700 (1968). The native portion of the run has ranged from 309 (1958) to 3,588 (1968) (Cramer and Cramer 1994; Weitkamp et al. 1995).

Coho are harvested in the ocean by both commercial and sport fisheries, in the Columbia by sport and gillnet fisheries, and in tributaries by sport fisheries. Coho in the Columbia River system have been managed primarily for hatchery production that can support high harvest rates (ODFW 1982). The highest harvest rates for Columbia River coho occurred in the 1970s (Table 4-8). Estimates of harvest rates used by ODFW have been termed "maximum" estimates, because a minor portion of the spawning escapement is not accounted for in the estimate.
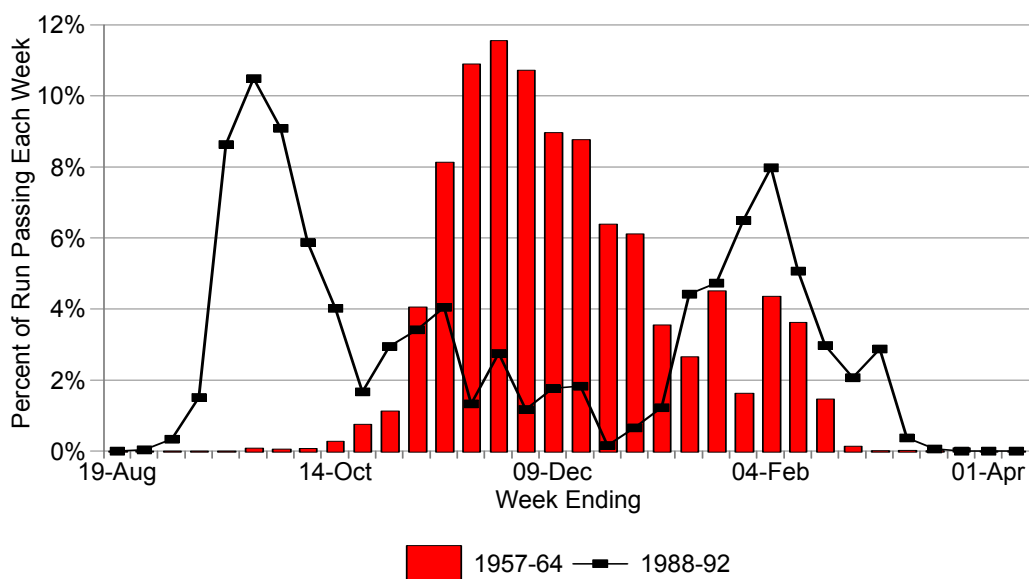
Figure 4-20.   Weekly proportion of the adult coho run that passed North Fork Dam on the Clackamas River, Oregon, during 1957-1964, compared to 1988-1992 (from Cramer and Cramer 1994).

Table 4-8.   Ten year means of estimated maximum inriver, ocean, and total proportion harvested for lower Columbia River coho, 1950 - 1989 (from ODFW 1990g).

Mean Maximum Proportion Harvested			
Catch of Years	**Inriver**	**Ocean**	**Total**
1950-1959	0.652	0.500	0.826
1960-1969	0.515	0.587	0.796
1970-1979	0.715	0.778	0.938
1980-1989	0.659	0.533	0.860
1950-1989	0.635	0.599	0.855

The timing of adult coho passage through the lower Columbia River is clearly shown from the timing of catch in the lower river gill net fishery. The best picture of differences in run timing between lower Columbia stocks was obtained in 1988 and 1989 when CWT adults included returning early-run hatchery stocks, late-run hatchery stocks, and late-run Clackamas wild stock. Native Clackamas River coho did not appear in the landings until mid-October when the fishing season was nearly complete (Figure 4-21). In contrast, harvest of early-run coho was highest when the harvest season opened in mid-September, and harvest of Cowlitz stock coho peaked in mid-October (Figure 4-21). Approximately 35 percent of the native Clackamas coho run was harvested in the gillnet fishery, compared to over 60 percent of the Cowlitz coho. Harvest rates for CWT native Clackamas coho were substantially lower than those for either Columbia River early-run coho or Columbia River late-run hatchery coho.

4.1.5.2.2 Hatchery Contribution To Natural Production

On average, more than 55 million coho salmon were released annually in southwest Washington and the Columbia River between 1987 and 1991 (Weitkamp et al. 1995). Fifteen state hatcheries rear coho in the lower Columbia River area, and they rear early and late-run stocks. The stocks reared at both Oregon and Washington hatcheries were all early run until the late 1960s when a later running stock was developed from the Cowlitz River. Thus, early run coho have been derived from many stocks, while late run hatchery coho are derived from the Cowlitz stock. The return timing of the Cowlitz hatchery stock is similar to that for wild coho in lower Columbia subbasins prior to the 1970s. The ocean distributions of early and late run differ (late fish use more northerly areas), as well as their spawning times (Cramer and Cramer 1994).

Extensive stock transfers have occurred within the lower Columbia River/Southwest Washington Coast ESU. Most transfers of coho salmon have used stocks from within the ESU, although transfers from outside have also occurred, including those from the Oregon coast, Olympic Peninsula, and Puget Sound/Strait of Georgia. Most movement of coho salmon, either as hatchery transfers or off-station releases, has occurred within three areas, with little movement of fish in-between: Oregon-side Columbia River, Washington-side Columbia River, and southwest Washington coast. The Clackamas River has also been extensively outplanted with early-running Columbia River stocks and was outplanted with coho salmon from the Oregon coast in 1967 (Weitkamp et al. 1995; Cramer and Cramer 1994).
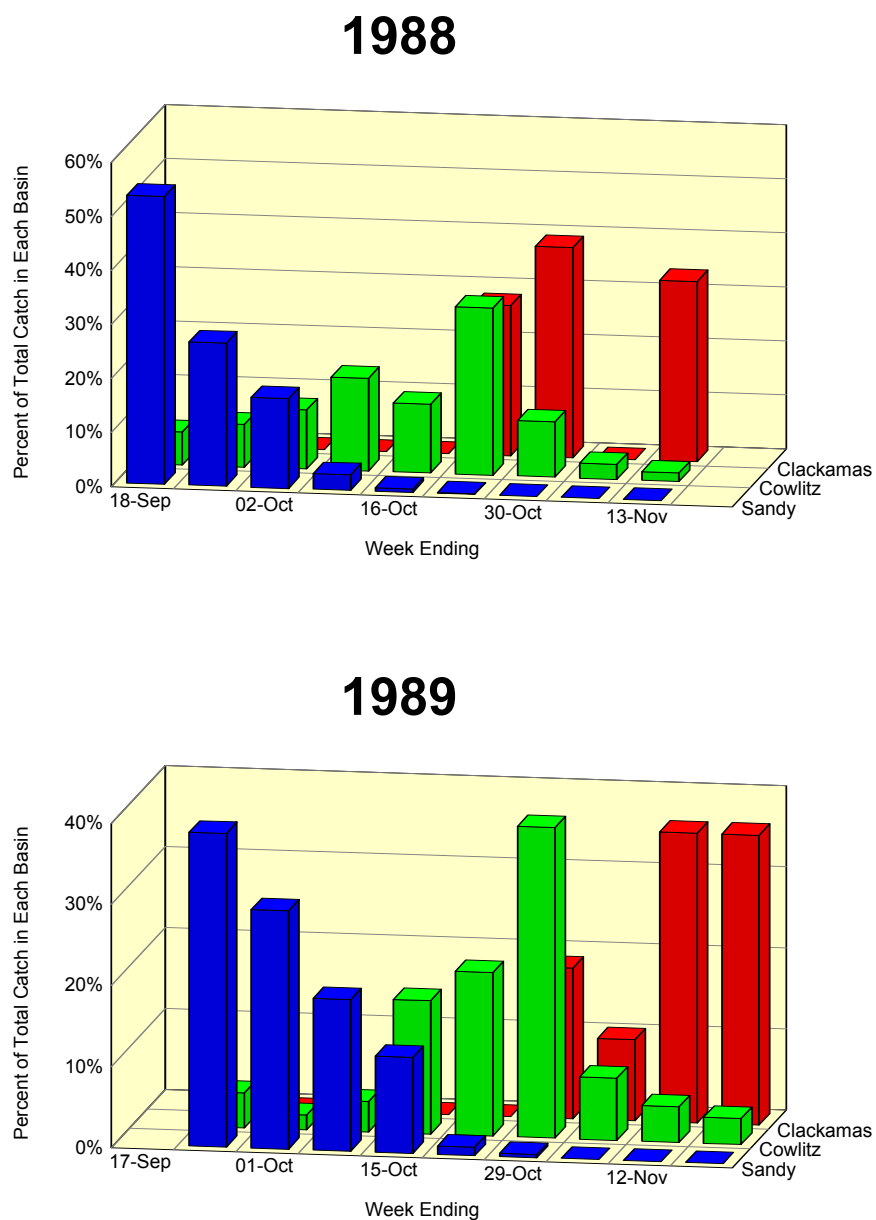
1988

1989

Figure 4-21.   Estimated weekly landings in the Columbia River of CWT coho Clackamas wild stock, Sandy Hatchery stock, and Cowlitz Hatchery stock during 1988 and 1989; (from Willis et al. 1995).

Over 10 million presmolts have been stocked annually into small streams within the lower Columbia River basin. It is believed that this practice may cause these streams to remain below juvenile carrying capacity because of concurrent low survival of hatchery fish and competitive displacement of resident fish into marginal habitats with low survival potential (Weitkamp et al. 1995).

Coho salmon have also been released extensively throughout the upper Willamette River basin in an attempt to establish populations above Willamette Falls. More than 1.4 million eggs, 55 million fry, 5 million fingerlings, 8 million yearlings, and 40,000 adult spawners were released between 1951 and 1980. Releases occurred in all of the major river basins containing USACE flood control projects (Williams 1983).

4.1.5.2.3 Current Hatchery Fish Releases

Early-run hatchery stock are still released into Clackamas tributaries below River Mill Dam. Eagle Creek National Fish Hatchery has been releasing coho into the Clackamas since 1957, and the predecessor to Eagle Creek National Fish Hatchery, Delph Creek Station, released coho beginning in 1946. In the early 1990s, approximately one million smolts have been released annually, and have produced an average return of 5,140 adults and 1,120 jacks since 1977 (ODFW 1992). Coho at Eagle Creek hatchery were mostly derived from early-run stock.

4.1.5.3 Life History

Coho generally have a three-year lifespan. Most coho salmon rear just over a year in freshwater, migrate to sea during April-May, rear about 1.5 years in the ocean, mature at age 3, and return in the fall to spawn in their natal streams. A variable proportion of the males in the population mature at age 2, and are termed "jacks."

4.1.5.3.1 Spawning

Most west coast coho salmon enter rivers in October and spawn from November to December, and occasionally in January. The Columbia River stock may have early (entering rivers in July or August) or late (spawning into March) runs in addition to normally timed runs. Coho salmon wait for freshets before entering rivers, where a delay in fall rains may delay river entry and spawn timing. Delays in river entry of over a month are not unusual. There is also considerable temporal variability in river entry and spawn timing, especially in large river systems such as the Columbia River. In general, earlier migrating fish spawn farther upstream within a basin than

later migrating fish, which enter rivers in a more advanced state of sexual maturity (Weitkamp et al. 1995). Coho salmon generally spawn in smaller tributary streams than chinook salmon (NRC 1996).

Differently-timed, sympatric runs in the Clackamas River may be reproductively isolated from each other (Cramer and Cramer 1994). The early run spawns in September through December, with peak activity occurring in October and November; the late run spawns from October through March, with peak activity occurring in February and March (Weitkamp et al. 1995).

Returning lower Columbia River coho salmon adults appear to be declining slightly in size over time, possibly because of selective fishing pressures (Weitkamp et al. 1995).

4.1.5.3.2 Incubation

Duration of incubation period for coho salmon varies widely with region and temperature. The average time from egg deposition to emergence has been found in Oregon coastal streams to be around 110 days (Koski 1966).

4.1.5.3.3 Juvenile Rearing and Outmigration

There does not appear to be any clear, regional pattern for either smolt outmigration timing or smolt size in west coast coho salmon. Peak outmigration timing generally occurs in May and June (Weitkamp et al. 1995). Juvenile coho in the Clackamas River are counted migrating downstream through the migrant bypass system of the North Fork Dam every month of the year; however, over 90 percent of the migration occurs in April and May (Cramer and Cramer 1994).

Smolts from southwest Washington tend to be relatively large, measuring 90-115 mm fork length, a possible result of the influence of off-station hatchery plants. Smolt outmigration timing and smolt size may be influenced by habitat conditions; smolts residing in ponds or lakes often have different outmigration timing and are a different size than smolts residing in streams within the same basin. Both smolt outmigration timing and size exhibit considerable interannual variation; mean smolt sizes from a single system can vary by over 15 mm between years, while peak outmigration timing can vary by several weeks to a month (Weitkamp et al. 1995).

4.1.5.3.4 Ocean Stage

Ocean distribution patterns show marked differences between areas of origin, and Columbia River fish are distributed differently from coastal Oregon and other regional stocks. Coho

salmon released from Columbia River hatcheries are recovered primarily in Oregon (36-67%) and Washington (22-54%), with lower but consistent recoveries from British Columbia (2-16%) and California (1-15%). Compared to Oregon coast coho salmon, Columbia River fish are recovered less frequently in California and more frequently in Washington. Although they share the same general recovery pattern, coho salmon from Washington-side Columbia River hatcheries are caught more frequently in Washington and British Columbia and less frequently in Oregon than those from Oregon-side hatcheries. This may be the result of a program aimed at increasing the Washington catch of Washington-produced Columbia River coho salmon (Weitkamp et al. 1995).

4.1.5.3.5 *Age At Maturity*

The majority of coho salmon adults are 3-year-olds, having spent approximately 18 months in fresh water and 18 months in salt water. The primary exception to this pattern are jacks, sexually mature males that return to freshwater to spawn after only 5-7 months in the ocean. The proportion of jacks in a given coho salmon population appears to be highly variable and may range from less than 6 percent to over 43 percent, based on over 9-35 years of monitoring (Weitkamp et al. 1995).

4.1.5.4 *Existing Recovery Efforts*

Anadromous fish from the Clackamas must pass through the lower Willamette River both on their way to and from the ocean. Beginning in the 1920s through the 1950s, water quality in the lower Willamette River deteriorated enough to cause a total block to fish passage during summer low flow periods (Willis et al. 1960). Depending on meteorological conditions, in some years, juveniles migrating after mid-June may have been lost, or the first returning adults in the fall delayed or lost due to pollution and low dissolved oxygen. These features of water quality in the Willamette River have improved substantially since 1960 and do not appear to be currently an impediment to migration.

Flow and temperature regimes in the Willamette have been drastically altered due to extensive development of flood control structures in the upper basin (Hughes and Gammon 1987). The mainstem channel of the Willamette has been highly modified by channelization projects and much of the riparian area has been lost to agricultural practices. This has altered runoff patterns and increased sediment loads. How this has affected Clackamas coho as they migrate through the Willamette is unknown.

Cramer and Cramer (1994) found a high correlation of outmigrant abundance to the number of spawners, with no indication that the number of smolts produced per spawner decreased at the highest spawning escapements observed since 1957. It was concluded that the availability of spawners has been the dominant factor limiting the production of coho in the Clackamas River basin.

NMFS concluded that if the Clackamas River late-run coho salmon is a native run that represents a remnant of a Lower Columbia River ESU, the ESU is not presently in danger of extinction but is likely to become so in the foreseeable future if present conditions continue (Weitkamp et al. 1995).

4.1.6 Columbia River Chum Salmon ESU

Chum salmon were abundant historically in the lower reaches of the Columbia River. Today, only remnant chum salmon populations exist, all in the lower Columbia River. They are few in number, low in abundance, and of uncertain stocking history. The lower Willamette River basin has been designated as critical habitat (65 FR 7764).

4.1.6.1 Subpopulations and Distributions

Allele-frequency data indicate that chum salmon from the Columbia River are genetically distinct from other West Coast ESUs. The nearest genetic neighbors of the Columbia River populations are found among the outer coast populations. Two major genetic groups are present in central and southern British Columbia, Washington, and Oregon. One consists of summer-run chum salmon in Hood Canal and the Strait of Juan de Fuca, and a second large group consists of fall-, winter-, and summer-run chum salmon in other areas. The second large group is weakly divided into two groups: 1) coastal populations along the outer coast of Washington and Oregon, including those in the Columbia River, and 2) the remaining populations in British Columbia and Washington (including the Strait of Juan de Fuca populations).

Genetic data available for two small Columbia River populations differ substantially from each other as well as from all other samples examined to date. Historically, there was at least one ESU of chum salmon in the Columbia River. Ecologically, Columbia River tributaries differ in several respects from most coastal drainages. Based upon the genetic and ecological data available, chum salmon in the Columbia River appear to be different enough from other populations in nearby coastal river systems (e.g., Willapa Bay, Grays Harbor, Nehalem River, and Tillamook River) that the Columbia River ESU extends only to the mouth of the river.

4.1.6.2 Population Trends

Population trends of Columbia River chum salmon have been influenced strongly by harvest and hatchery production, as described below. The 1994 biennial report on wild fish status in Oregon considered chum salmon populations in the Columbia River to be very depressed to extinct (Kostow 1995).

4.1.6.2.1 Run and Catch Sizes

Monitoring of chum salmon returns to three streams in the Columbia River suggest that there may be a few thousand to ten thousand spawning annually in the Columbia River basin (WDF et al. 1993; Hymer 1993, 1994). Minimal run size for chum salmon returning to both the Oregon and Washington sides of the Columbia River in 1995 was estimated to be 1,500 adult fish, and the chum salmon run size in the Columbia River appears to have been relatively stable at low levels since the run collapse that occurred in the mid-1950s (ODFW and WDFW 1995; Johnson et al. 1997).

The Columbia River historically contained large runs of chum salmon that supported a substantial commercial fishery in the first half of this century. More than 500,000 chum salmon were harvested in some years. Harvests tailed off in the late 1950s and early 1960s when the run collapsed. There are presently neither recreational nor directed commercial fisheries for chum salmon in the Columbia River, although some are taken incidentally in gill-net fisheries for coho and chinook salmon, and there has been minor recreational harvest in some tributaries (WDF et al. 1993).

4.1.6.2.2 Hatchery Contribution To Natural Production

Little artificial propagation of chum salmon has occurred in the Columbia River compared to other areas in the Pacific Northwest, and this has usually been conducted in areas that no longer contain native chum salmon stocks. From 1930 to 1991 an average of 485,000 chum salmon fry were released annually (Johnson et al. 1997); between 33,400 and 914,000 fry were released annually in Oregon from the 1977-1982 brood years (Howell et al. 1985b). Historically, chum salmon were reported to be present in almost every river in the lower Columbia River basin, but most of these runs disappeared by the 1950s (Rich 1942; Marr 1943; Fulton 1970). On the Washington side of the lower Columbia River, only three streams are recognized as presently

containing native chum salmon: Hamilton and Hardy creeks near Bonneville Dam and the Grays River (WDF et al. 1993).

Historical plants of non-native hatchery chum salmon into the Columbia River basin have been comprised of fish from the coast, Hood Canal, and a small portion of Japanese origin. However, these fish are not believed to have hybridized with local populations for several reasons. Hatchery fish were planted to supplement fisheries only in areas without native chum salmon and in areas where spawning was poor or nonexistent (WDF et al. 1993). Recent genetic analysis of fish from Hardy and Hamilton creeks and from the Grays River also indicate that these fish are genetically distinct from other chum salmon populations in Washington (WDF et al. 1993; Phelps et al. 1994; Johnson et al. 1997).

About 23 populations of chum salmon have been reported on the Oregon side of the Columbia River (Kostow 1995). Big Creek and the Klaskanine River (a tributary to the Youngs River) are the only systems that have received significant numbers of hatchery chum salmon. In both cases, local fish were used for supplementation (Johnson et al. 1997).

Chilcote et al. (1992) listed an inventory of chum salmon runs in Oregon and evaluated them under the Oregon Wild Fish Policy (Kostow [1995] is a revision of Chilcote et al. [1992], with newer information on stock presence or absence). This policy has two compliance criteria: a hatchery criterion that requires naturally spawning populations to have no more than 10 percent strays from a genetically-dissimilar hatchery stock or 50 percent strays from a genetically-similar hatchery stock, and a numerical criterion that requires at least 300 average spawners. Chilcote et al. (1992) considered the percentages of hatchery strays and their genetic constitution in all chum salmon runs in Oregon to be in compliance with hatchery criteria. Of 50 populations of chum salmon identified in Oregon, they considered 4 to be in compliance with the numerical criterion and 4 out of compliance. The remaining 42 populations were of unknown status (Johnson et al. 1997).

4.1.6.2.3 Current Hatchery Fish Releases

At present, only a single cooperatively owned hatchery on the Chinook River (a tributary to the Columbia) produces hatchery chum salmon for the Columbia River and propagates chum salmon imported from Willapa Bay. Approximately 360,500 chum salmon fry were released annually by this hatchery between 1982 and 1991 (WDF et al. 1993).

4.1.6.3 Life History

4.1.6.3.1 Spawning

Columbia River chum salmon spawn most commonly in the lower reaches of rivers, with redds usually constructed in reaches located just above tidal influence, and less than 100 km from the sea. Presently, most appear to spawn within 16 km of river mouths (WDF et al. 1993). Chum salmon are believed to spawn primarily in the lower reaches of rivers because they are reluctant or unable to negotiate river blockages and falls. It has been suggested that they may go upstream as far as they can toward natal areas and spawn once they reach a barrier. There are reports that chum salmon in the Columbia River basin, may historically have spawned in the Umatilla and Walla Walla rivers, more than 500 km from the sea (Nehlsen et al. 1991), but these fish would have had to pass Celilo Falls under specific high water conditions (Johnson et al. 1997). There is no evidence that chum salmon spawned historically above Willamette Falls.

Chum salmon enter natal river systems between June and March, with exact timing depending on characteristics of the population or geographic location. Chum salmon in the Columbia River are limited to tributaries below Bonneville Dam, with the majority of fish spawning on the Washington side of the Columbia River where they enter tributaries from late September through November (peak occurs in mid-November). Fish on the Washington side have a relatively protracted spawning period extending between mid-November and mid-January. The ODFW cited 25 locations in Oregon where chum salmon spawn in the lower Columbia River, but information on run and spawning times for these fish is unavailable (Kostow 1995; Johnson et al. 1997).

In the past, chum salmon were thought to have a greater tendency to stray than other species of Oncorhynchus although recent studies have concluded that straying in chum salmon under normal circumstances is no greater than in any other. Straying to nearby streams may increase when spawning densities of chum salmon become high in some rivers, particularly those with hatchery runs (Johnson et al. 1997).

There are several unique features of the chum salmon spawning life history stage compared to chinook and coho salmon and steelhead trout. Chum salmon spawn near the mouths of streams, so their young do not conduct the long, downstream, freshwater migrations that are common in many other anadromous salmonid species. Adult chum salmon also are more sexually mature when they enter freshwater than most species of anadromous salmonids and may not be able to

endure delays in reaching their natal areas; if delayed, they may be forced to spawn at the first available location (Johnson et al. 1997).

4.1.6.3.2 Incubation

The rate of embryonic development in chum salmon is influenced most by water temperature. The amount of heat required by fertilized chum salmon eggs to develop and hatch is about 400-600 TUs, and the heat required to complete yolk absorption is about 700-1,000 TUs. Lower water temperatures can prolong the time required from fertilization to hatching by 1.5-4.5 months. For example, fertilized eggs hatch in about 100-150 days (400-600 TUs) at 4°C, but hatch in only 26-40 days at 15°C (Johnson et al. 1997).

4.1.6.3.3 Juvenile Rearing and Outmigration

Chum salmon fry spend very little time in freshwater and migrate to estuaries soon after emergence. Relatively little is known about fry emigration. Chum salmon outmigrants are generally smaller than outmigrants of other salmonids, migrate at night, and have typically shorter distances to migrate to reach saltwater than other species (Johnson et al. 1997). Downstream migration may take only a few hours or days in rivers where spawning sites are close to the mouth of the river. The timing of outmigration is usually associated with increasing day length, warming of estuarine waters, and high densities of plankton. Juvenile chum salmon in Washington generally migrate downstream from late January through May (Johnson et al. 1997).

Chum salmon juveniles, like other anadromous salmonids, use estuaries to feed before beginning long-distance oceanic migrations. However, chum salmon may have longer residence times in estuaries than other anadromous salmonids except ocean type chinook salmon. The period of estuarine residence appears to be the most critical phase in the life history of chum salmon and may play a major role in determining the size of the subsequent adult run back to freshwater. Although chum salmon do not have clearly defined smolt stages, they are capable of adapting to seawater soon after emergence. The capability of chum salmon fry for early osmoregulation in seawater may be important for adult homing back to natal streams (Johnson et al. 1997).

4.1.6.3.4 Ocean Stage

Very little information is available regarding the distributions of specific regional populations of chum salmon from Washington and Oregon. North American chum salmon have been found rarely west of the mid-Pacific Ocean beyond longitude 175°E. Maturing chum salmon in the

North Pacific begin to move coastward in May and June and enter coastal waters from June to November. It is unknown, but has been speculated that Columbia River fish had a more southern ocean distribution and may have returned northward along the Oregon coast in a manner similar to Columbia River coho salmon (Johnson et al. 1997).

4.1.6.3.5 Age At Maturity

Age at maturity appears to follow a latitudinal trend in which a greater number of older fish occur in the northern portion of the species' range. Chum salmon generally mature between 3 and 5 years of age, with the majority maturing at 4 years of age. There is a higher proportion of 3-year-old fish in the south (southern British Columbia, Washington, Oregon), and a higher proportion of 5-year-old fish further north. Fluctuations observed in age composition may be explained by differences in abundances between brood years. Adult chum salmon have been decreasing in size and average age throughout their range since the early 1980s, although there is evidence of an increase again in recent years. The changes are suspected to be linked to changes in the North Pacific Ocean climate regime and conditions (Johnson et al. 1997).

4.1.6.4 Existing Recovery Efforts

Differences of opinion exist regarding the present degree of extinction risk for the Columbia River Chum Salmon ESU. Current abundance is probably less than 1 percent of historic levels, and the ESU has undoubtedly lost some (perhaps much) of its original genetic diversity. Presently, only three chum salmon populations, all relatively small and all in Washington, are recognized and monitored in the Columbia River (Grays River, Hardy and Hamilton creeks). Each of these populations may have been influenced by hatchery programs and/or introduced stocks, but information on hatchery-wild interactions is unavailable. Although current abundance is only a small fraction of historical levels, and much of the original inter-populational diversity has presumably been lost, the total spawning run of chum salmon to the Columbia River has been relatively stable since the mid 1950s, and total natural escapement for the ESU is probably at least several thousand fish per year (Johnson et al. 1997).

Bonneville Dam presumably continues to impede recovery of upriver populations. Substantial habitat loss in the Columbia River estuary and associated areas presumably was an important factor in the decline and also represents a significant continuing risk for this ESU.

Restoration plans for steelhead in the lower Columbia River are being developed by Washington and Oregon. There is considerable potential for these plans to promote recovery of chum salmon

as well. The WDFW and USFWS have undertaken several habitat enhancement projects aimed at restoring chum salmon populations in Hamilton and Hardy creeks, but comparable projects are not underway in Oregon that are targeted specifically for chum salmon. The species has been placed on the state of Oregon list of sensitive fish species (Kostow 1995), but does not receive substantial or specific protection.

4.1.7 Columbia River Bull Trout DPS

Bull trout in the Willamette River basin are considered members of the Columbia River Bull Trout Distinct Population Segment (DPS). This DPS is represented by relatively widespread, geographically isolated subpopulations throughout the entire Columbia River basin within the United States and its tributaries, excluding bull trout found in the Jarbidge River, Nevada (63 FR 31647). Bull trout were likely distributed historically throughout the Willamette River basin, including in west side tributaries (Buchanan and Hemmingsen 1995).

4.1.7.1 Subpopulations, Distributions, and Genetic Interactions

The Columbia River bull trout DPS is comprised of 141 subpopulations. These subpopulations are geographically and reproductively isolated, residing in restricted habitats typically in the upper reaches of tributaries to the Columbia and Snake rivers. The Willamette River basin historically contained bull trout populations in the Clackamas River, North Santiam River, South Santiam River, McKenzie River, Middle Fork Willamette River, and Long Tom river basins (Table 4-9; Goetz 1994). Although possible because documentation of bull trout distributions has been generally poor overall, there is no evidence of bull trout having resided in the Coast Fork Willamette River basin. The McKenzie River basin currently supports the only known, remaining viable bull trout populations in the Willamette River basin (Buchanan et al. 1997). Goetz (1994) noted that bull trout in the Middle Fork Willamette River basin at that time occupied approximately 15 percent of their former range there. More recently, the status of bull trout in the Middle Fork Willamette River basin has been changed from "high risk" to "probably extinct" (Buchanan et al. 1997) and will likely remain that way unless recent fry reintroduction efforts above Hills Creek Reservoir succeed (Taylor and Reasoner 1998). The status of bull trout in the Santiam River system is "probably extinct" (Buchanan et al. 1997). The ODFW continues to survey for bull trout in these basins.

Historically, the McKenzie River probably supported one or two fluvial populations prior to dam construction. Presently, three specific sub-populations of bull trout have been identified in the McKenzie River system (Buchanan et al. 1997) including: (i) the middle McKenzie River basin

Table 4-9. Reported historic distribution of bull trout in the Willamette River basin.

Subbasin Mainstem Tributary	Status	Reference
Lower Willamette River	Extinct	
Buck Creek	Extinct	J. Massey, ODFW, pers. comm. 1992 (cited in Goetz 1994)
Lower Clackamas River	Extinct	Jordan (1907)
Upper Clackamas River	Extinct	Annual Report of the Oregon State Game Commission (1960)
Oak Grove Fork Clackamas River	Extinct	C. Campbell, OGC, unpublished data (cited in Goetz 1994)
Santiam River	Probably extinct	
Lower North Santiam River	Probably extinct	B. Sanderson, pers. comm. 1992 (cited in Goetz 1994)
Upper North Santiam River	Probably extinct	A. Girard, pers. comm. 1992 (cited in Goetz 1994)
Breitenbush River	Probably extinct	D. Hurt, pers. comm. 1992 (cited in Goetz 1994)
South Santiam River	Probably extinct	Annual Report of the Oregon State Game Commission (1953)
McKenzie River		
Middle McKenzie River & Leaburg Lake	Special concern	ODFW (cited in Goetz 1994); Buchanan et al. (1997)
Blue Creek	Special concern	Buchanan et al. (1997)
Lower SF McKenzie River	Special concern	S. Gregory, OSU, unpub. data (cited in Goetz 1994); Buchanan et al. (1997)
Upper SF McKenzie River	High risk of extinction	(cited in Goetz 1994); Buchanan et al. (1997)
Cougar Reservoir	High risk of extinction	Ratliff and Howell (1992); Buchanan et al. (1997)
French Pete Creek	High risk of extinction	Kivett (1964); Buchanan et al. (1997)
Roaring River	High risk of extinction	(cited in Goetz 1994); Buchanan et al. (1997)
Horse Creek	Special concern	Buchanan et al. (1997)
Separation Creek	Special concern	ODFW (cited in Goetz 1994); Buchanan et al. (1997)
Lost Creek	Special concern	Buchanan et al. (1997)
Deer Creek	Special concern	Buchanan et al. (1997)
Olallie Creek	Special concern	(cited in Goetz 1994); Buchanan et al. (1997)
Anderson Creek	Special concern	(cited in Goetz 1994); Buchanan et al. (1997)
Upper McKenzie River	High risk of extinction	(cited in Goetz 1994); Buchanan et al. (1997)
Trail Bridge Reservoir	High risk of extinction	(cited in Goetz 1994); Buchanan et al. (1997)
Sweetwater Creek	High risk of extinction	Buchanan et al. (1997)
Smith Reservoir	High risk of extinction	Annual Report of the Oregon State Game Commission (1963)

Table 4-9. Reported historic distribution of bull trout in the Willamette River basin.

Subbasin	Status	Reference
Mainstem		
Tributary		
Carmen Reservoir	High risk of extinction	Annual Report of the Oregon State Game Commission (1965)
Middle Fork Willamette River	Probably extinct	Ratliff and Howell (1992)
Dexter Reservoir	Probably extinct	D. Maher, Dexter Fish Hatchery, pers. comm. 1990 (cited in Goetz 1994)
Lookout Point Reservoir	Probably extinct	D. Maher, Dexter Fish Hatchery, pers. comm. 1990 (cited in Goetz 1994)
Fall Creek Reservoir	Probably extinct	M. Wade, ODFW, pers. comm., 1993 (cited in Goetz 1994)
Salmon Creek	Probably extinct	Buchanan et al. (1997)
Salt Creek	Probably extinct	Annual Report of the Oregon State Game Commission (1960)
Hills Creek Reservoir	Probably extinct	(cited in Goetz 1994)
Staley Creek	Probably extinct	R. Swan, OGC, unpublished data (cited in Goetz 1994)
Swift Creek	Probably extinct	R. Swan, OGC, unpublished data (cited in Goetz 1994)
NF of the Middle Fork Willamette	Probably extinct	Annual Report of the Oregon State Game Commission (1962)
Long Tom River	Probably extinct	Annual Report of the Oregon State Game Commission (1962)

between Leaburg and Trail Bridge dams, including Olallie Creek, Anderson Creek, Horse Creek, Deer Creek, and the lower South Fork McKenzie below Cougar Dam; (ii) the upper McKenzie River basin above Trail Bridge Dam up to Tamolitch Falls, a natural barrier, including Sweetwater Creek that flows into Trail Bridge Reservoir; and (iii) the South Fork McKenzie River basin above Cougar Dam, including the Roaring River. The first sub-population was considered to be at moderate risk of extinction but has recently been upgraded to "special concern" status. The status of the other two subpopulations has been downgraded and are now considered to be at "high risk" of extinction (Buchanan et al. 1997). The South Fork McKenzie River sub-population is considered to be essentially isolated from the other two sub-populations by the dam.

Nuclear DNA analysis of bull trout populations in Oregon and selected rivers in Washington indicate that the McKenzie River bull trout are part of a "coastal" group of bull trout populations that shows substantial differences from "inland" bull trout (Buchanan et al. 1997; Spruell and Allendorf 1997). Variation among the "coastal" populations indicate that the Willamette drainage fish also exhibit noticeable allele distribution differences from other coastal populations sampled. Bull trout collected from the McKenzie River system are most closely related genetically to bull trout collected in the Lewis River and Deschutes River systems (Spruell and Allendorf 1997).

Bull trout interbreed readily with non-native brook trout *(Salvelinus fontinalis),* and may be competitively excluded by them (Buckman et al. 1992; Dambacher et al. 1992). Hybrid bull x brook trout adults are more likely than not to be infertile (Dambacher et al. 1992). Brook trout occur in the mainstem McKenzie above Trail Bridge Dam and have been planted in High Cascades lakes throughout the McKenzie River subbasin. ODFW has ceased stocking brook trout in lakes where brook trout could access tributaries to the McKenzie River. Limited hybridization appears to have occurred in the mainstem. Occasional sightings of hybrids have been documented in the mainstem river below Trail Bridge Dam and near the mouth of Lost Creek. Although brook trout spawn in the upper McKenzie River system, there is no evidence of hybridization occurring, possibly because brook trout tend to spawn slightly later than bull trout in this area, peaking in November. Brook trout presence has not been documented in the South Fork McKenzie above Cougar Dam, despite their having been planted in high mountain lakes within the upper drainage (Unthank 1998).

4.1.7.2 Population Trends

Bull trout populations have undergone severe declines in the Willamette River basin. Goetz (1994) proposed that the construction of dams was the primary factor reducing bull trout abundance and distribution range because of the resulting migratory blockage influencing access to spawning and rearing habitat and interchange between migratory populations, and changes in temperature regime, introduction or establishment of exotics, water diversions, and other indirectly related factors. The average time to extirpation was calculated to be nearly 9 years after dam construction, with 15 years being the longest observed.

Decreases in juvenile chinook and steelhead abundance have been implicated in the decline of bull trout populations in the same stream systems because adult bull trout are known to feed on juvenile chinook, where it has been inferred that the decreases have been partly a result of a reduced forage base (Ratliff and Howell 1992). Sympatric decreases in abundance have also been hypothesized because of reduced nutrient loading from adult chinook salmon carcasses (ODFW 1997b). Decreased delivery of marine-based nitrogen, phosphorous, and other elements has been correlated with decreased escapement of salmon to Pacific Northwest streams (Gresh et al. 2000). There is equivocal evidence regarding the importance of carcasses to stream ecosystems and salmonid production, however. Bilby et al. (1998) determined higher fish densities and condition factors of juvenile coho salmon and steelhead trout in streams where carcasses had been added than in streams where they had not. There is also evidence that nutrients are not limiting growth rates of juvenile salmonids in streams with seriously depleted anadromous populations in Idaho, for example (D. Schill, Idaho Department of Fish and Game, Nampa, personal communication, January 2000). Bull trout feeding behavior is relatively plastic, where they can feed readily on other items than chinook juveniles or eggs, such as sculpin, longnose dace, and insects.

The middle McKenzie River subpopulation below Trail Bridge Dam appears to be stable or increasing, based on an increasing trend in redd counts in Anderson Creek (Buchanan et al. 1997; ODFW 1999b). The current population trends of the other two subpopulations are unknown, but are considered to be at high risk of extinction due to isolation, low abundance, and limited spawning habitat. Spawning activity in the South Fork McKenzie River subpopulation has been documented in the Roaring River (Buchanan et al. 1997). However, redd counts have been extremely low. The USACE is helping to fund research investigations in an effort to learn more about the South Fork McKenzie River subpopulation located above Cougar Dam. Table 4-10 summarizes the status of bull trout in the McKenzie River system.

Table 4-10.   Summary of Bull Trout Populations - McKenzie River, Oregon (Taylor and Reasoner 1998; Unthank 1998, 1999).

Available Information	Mainstem McKenzie below Trail Bridge Dam	Mainstem McKenzie above Trail Bridge Dam	South Fork McKenzie above Cougar Dam
Years monitored with redd counts	1989-1999	1995-1999	1994-1999
Redd count trend	Increasing to Steady	Decreasing or Unknown	Decreasing or Unknown
Snorkel monitoring of index pools – number of adults encountered in one day (1994-1998)	1994 peak = 32 1995 peak = 33 1996 peak = 36 1997 peak = 19 1998 peak = 30		1994 total = 3 1995 peak = 17 1996 peak = 9 1997 peak = 10 1998 peak = 17
Population Status (ODFW 1997a)	Special concern	High risk of extinction	High risk of extinction

4.1.7.2.1 Population Size and Redd Counts

The population of mature bull trout in the entire McKenzie River basin has been estimated at less than 300 individuals spawning annually, of which between 25 to 75 are found in the South Fork McKenzie River system (ODFW 1999b). The Middle McKenzie River subpopulation is the most robust of the three subpopulations. Spawning activity has been documented in Anderson and Olallie creeks, with an estimated average annual production of approximately 22,000 fry from 1997 through 1999. In addition, juvenile trapping by ODFW resulted in an average expanded catch of 289 yearling and older fish occurring in Anderson Creek over the period 1994 through 1998 (ODFW 1999b; Figure 4-22). Based on an increasing trend in redd counts, large numbers of juvenile fish, an increase in the availability and use of spawning habitat in Olallie Creek, and the potential for re-connecting the basin's three subpopulations, the USFWS does not consider the Middle McKenzie subpopulation to be at high risk of extinction.

Bull trout in the South Fork McKenzie River subpopulation have been isolated from the other two McKenzie River subpopulations since the completion of Cougar Dam in 1963. Bull trout are known to occur in Cougar Reservoir and have been caught by anglers both in and above the reservoir since the completion of the dam. The abundance of bull trout in Cougar Reservoir is unknown, but was estimated at between 100 and 500 fish by ODFW (USACE 1995a). The abundance of bull trout in the watershed above Cougar Reservoir is currently extremely low.
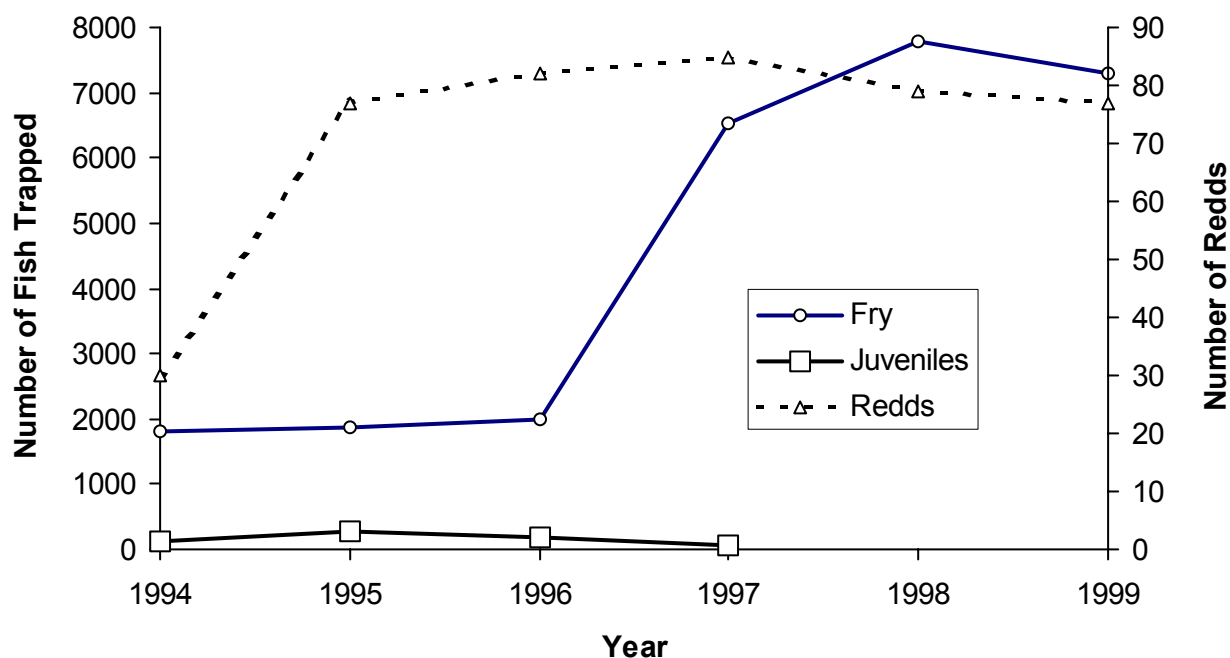
Figure 4-22.   Bull trout population survey data collected in Anderson Creek, Oregon, 1994-1999 (data from Taylor and Reasoner 1998; Unthank 1999).

4.1.7.2.2 Past and Current Stocking Practices

Bull trout have not been propagated artificially in the past, and were even once subject to capture bounties in the belief that they were harming chinook salmon reproduction. Stocking of catchable rainbow trout is believed to have added pressure to native bull trout populations both through competition and increased angling activity, but has been stopped recently in the upper and South Fork McKenzie River systems. Also recently, the USFS has transferred bull trout fry from the McKenzie system to likely juvenile habitat in the Middle Fork Willamette River system above Hills Creek Reservoir, and from Anderson Creek to Sweetwater Creek and Olallie Creek in an effort to boost or reestablish populations in underutilized or unused habitat (Buchanan et al. 1997; ODFW 1999b).

4.1.7.3 Life History

Columbia River bull trout exhibit three life-history patterns, resident, fluvial, and adfluvial. However, only the migratory life history form has been documented in the McKenzie River basin. Both river- (fluvial) and lake-dwelling (adfluvial) migratory life history patterns occur in the basin, including fish that migrate past Leaburg Dam (four and nine bull trout were counted

migrating upstream in 1997 and 1998, respectively; ODFW 1999b). Resident populations of bull trout confine their migrations to within their natal stream. Fluvial populations usually migrate between their natal streams used for spawning and early juvenile rearing, and large rivers used for adult rearing. Adfluvial populations usually migrate between their natal streams used for spawning and early juvenile rearing, and lakes or reservoirs used for adult rearing (Buchanan et al. 1997). Anadromy is not currently found in Columbia River bull trout populations, although Bond (1992) believed that anadromy occurred historically. Buchanan et al. (1997) observed that fluvial populations can become adfluvial populations under some circumstances, such as the isolation of populations above dams. Both fluvial and adfluvial life history strategies can occur within the same population. The McKenzie River populations were likely to have originally been of the fluvial form (Buckanan et al. 1997). It is probable that the subpopulations above Cougar and Trail Bridge dams have become closer to the adfluvial form because of the availability of lake habitat and the influence of adverse winter instream habitat conditions at higher elevations.

Bull trout have been observed to have more specific habitat requirements than do other salmonid species (Rieman and McIntyre 1993). Habitat components that influence bull trout abundance and distribution include water temperature, shelter, channel form and stability, valley form, spawning and rearing substrates, and migratory corridors (63 FR 31647). They are found primarily in cold streams. Water temperature above 15.0°C is likely to limit bull trout distribution (Fraley and Shepard 1989). Goetz (1989) suggested optimum water temperatures for rearing of 6.7-7.8°C.

Bull trout co-evolved with chinook salmon. Although they have been noted to utilize similar macrohabitats during certain periods of their life history, this habitat sharing does not appear to adversely affect bull trout because the two species occupy different microhabitats, which may reduce interspecies competition (Underwood et al. 1995).

4.1.7.3.1 *Spawning*

Spawning in most bull trout populations occurs from August to November during periods of decreasing water temperatures. McKenzie River adult fish generally migrate from overwintering areas beginning in June, although radio-tracking studies in 1998 noted upstream migration beginning in May (Taylor and Reasoner 1998). The peak of migration towards spawning areas occurs during the months of July and August for the mainstem McKenzie population. Bull trout stage in large pools in the McKenzie River below Anderson and Olallie creeks before spawning (ODFW 1999b). The upper South Fork McKenzie population's peak migratory movement has

been observed to occur in late June (Buchanan et al. 1997; Unthank 1998), but mature bull trout have been observed migrating upstream from Cougar Reservoir as early as April and May (J. Ziller, ODFW, personal communication).

Spawning of mainstem fish in Anderson and Olallie creeks begins in September and may continue into early November, with a peak in late September–early October (Taylor and Reasoner 1998). The peak of spawning in the McKenzie River system usually occurs in early September to early October. Spawning is generally initiated as stream temperatures decline below 10ºC. Spawning occurs primarily in spring-fed tributaries (Anderson, Olallie, and Roaring River) or in areas with ground-water influence (the mainstem McKenzie above Trail Bridge Reservoir) with temperatures between 5° and 8°C (Pratt 1992; Buchanan et al. 1997; Unthank 1998). ODFW reported observing 36 spawners during the fall of 1999 in the Roaring River.

Most bull trout populations generally include stream resident fish that spawn every year (Armstrong and Morrow 1980), although there is documentation that some fish may spawn in alternate years (Rose and Rose 1997). Repeat spawning frequency and post-spawning mortality rates are not well documented (63 FR 31647), and little to nothing is known regarding these characteristics in the Willamette system.

The upper and South Fork McKenzie River populations are believed to be limited by spawning habitat availability. Bull trout have been noted to spawn rarely in the South Fork McKenzie River mainstem above Cougar Reservoir (Buchanan et al. 1997). Other potential spawning streams include Horse Creek, Separation Creek, Lost Creek, and Sweetwater Creek. Removal of culvert barriers has opened up more spawning habitat in Olallie and Sweetwater creeks (Buchanan et al. 1997; Unthank 1998). No spawning has occurred yet in Sweetwater Creek since fry were transplanted. Adults were expected to begin returning to spawn there in 1999 (ODFW 1999b), but no redds were observed (J. Ziller, ODFW Springfield, personal communication, January 2000).

4.1.7.3.2 Incubation

Bull trout eggs require approximately 350-440 TUs (based on °C) to hatch. Embryos incubate for approximately 100-145 days usually, and as much as 200 days, and hatch in late winter or early spring. The alevins remain in the streambed, absorbing the yolk sac, for an additional 65-90 days, and emergence from the streambed occurs in late winter/early spring (Pratt 1992; Buchanan and Hemmingsen 1995; Buchanan et al. 1997; Unthank 1998).

4.1.7.3.3 Juvenile Rearing and Migration

Young-of-the-year (YOY) bull trout are found primarily in side channel areas and along stream margins (Fraley and Shepard 1989). Juveniles (smaller than 100 mm in length) are primarily bottom dwellers and are found among coarse substrate (Fraley and Shepard 1989; Pratt 1992). Goetz (1989) stated that optimum water temperatures for rearing were about 7EC to 8EC. Older, large individuals are often found in deeper stream pools or in lakes in deep water with temperatures less than 15EC (Pratt 1992). Anderson Creek juvenile populations may be currently at carrying capacity (ODFW 1999b).

Juvenile migratory bull trout can spend from several months to several years in natal stream areas before emigrating into larger rivers or lakes (Scott and Crossman 1973). Migration into the larger McKenzie River generally occurs at ages 2-3 (Unthank 1998). Juvenile migrations from natal areas may occur during spring, summer, or fall (Pratt 1992). Two migration patterns have been identified in Anderson Creek: the first, by fry approximately 30 mm long with peak movement in late March and early April; the second by fish 70-100 mm in length (possibly age 1+ and 2+) in late May and again in August (ODFW 1997b). Most migration activity probably occurs at night (Ratliff et al. 1996). Migratory corridors link seasonally important habitats for all bull trout life history forms (Fraley and Shepard 1989). The ability to migrate, forming population networks or metapopulations, is particularly important to the persistence of local bull trout sub-populations (Rieman and McIntyre 1993).

4.1.7.3.4 Lake and Fluvial Stage

Bull trout have the potential to grow to a large size in lakes and large rivers, as much as 800 mm fork length. Reports exist of large adults residing historically in the upper McKenzie River and Middle Fork Willamette River mainstems (Buchanan et al. 1997). The largest adult captured in a survey in 1995 was in the South Fork McKenzie River and was 411 mm long (Hemmingsen et al. 1996).

There is recent evidence that adult bull trout from the mainstem McKenzie River population over-winter at the same location in consecutive years (Taylor and Reasoner 1998).

4.1.7.3.5 Age at Maturity

Bull trout populations are known to exhibit multiple, complex life history traits including multiple life history forms, complex age structures, and complex maturation schedules (Rieman and McIntyre 1993). They may reach sexual maturity between the ages of four to nine years (Williams and Mullan 1992; Pratt 1992; WDW 1993). Males often mature a year earlier than females (Scott and Crossman 1973). Bull trout may often live 10 to 12 years (Scott and Crossman 1973), and could live as long as 20 years (Carlander 1953) depending on the accuracy of age estimation techniques.

4.1.7.4 Existing Recovery Efforts

Although critical habitat for bull trout has not yet been designated by the USFWS, "the present or threatened destruction, modification, or curtailment of bull trout habitat" was identified by USFWS as one of the principle factors affecting the species (63 FR 31647). The three subpopulations of bull trout identified by the USFWS that occur in the McKenzie River basin constitute the last known self-sustaining population group in Oregon west of the Cascade Mountain Range. All of the occupied habitat in the McKenzie River basin is obviously critical to the persistence of this population group.

A working group comprised of representatives from federal, state, industry, and environmental groups has been formed to coordinate work on bull trout protection and recovery, and to draft a conservation strategy for the Willamette River basin. Several restoration projects have been completed, including passage barrier correction in Sweetwater Creek, a designated Key Watershed in the Forest Plan where habitat is protected from land use effects, and in Olallie Creek. Recent fry transplanting efforts are intended to help restore extirpated or depleted populations. Nearly 1,500 fry were transplanted from Anderson Creek in the McKenzie River subbasin to the upper Middle Fork Willamette River subbasin above Hills Creek Reservoir in 1998 (Taylor and Reasoner 1998). Fry have also been transplanted from Anderson Creek to Sweetwater and Olallie creeks. Changes in angling regulations have been imposed, including stopping of angling in the South Fork McKenzie River, and stocking of catchable trout has ceased in areas important to bull trout. Future plans include continued studies of life history, population distributions, and habitat, as well as continued reintroduction efforts in the Middle Fork Willamette River basin and other restoration projects, and reducing camping activity on USFS land in the vicinity of important bull trout spawning areas (Buchanan et al. 1997; Unthank 1998). Increased enforcement to reduce poaching is also planned (ODFW 1997b). State of

Oregon recovery plans are also directed at reintroducing bull trout to the Santiam and Clackamas river basins (M. Hanson, ODFW Portland, personal communications from January 2000).

4.1.8 Southwest Washington/Lower Columbia Cutthroat Trout ESU

Much of the available information for coastal cutthroat trout is qualitative or descriptive, rather than quantitative. Comprehensive data are generally absent regarding distribution, abundance, age structure, and run timing. This is, in part, because coastal cutthroat trout do not constitute a commercially important species, and have fewer directed recreational fisheries than co-occurring Pacific salmon and steelhead. Furthermore, spawning coastal cutthroat trout are more difficult to observe than spawning salmon, and there are almost no large runs that are clear targets for systematic monitoring (Johnson et al. 1999).

4.1.8.1 Subpopulations and Distributions

Unlike other West Coast species of Pacific salmon, coastal cutthroat trout show evidence of widespread hybridization with rainbow or steelhead trout, and genetic differentiation has been a difficult task. Cutthroat trout from southwestern Washington coast, the Lower Columbia River, and the Willamette River appear to be related more to each other than to fish from other regions. Of these, southwestern Washington and Lower Columbia River fish appear to be most closely related. Coastal cutthroat trout from the lower Willamette River drainage appear to be generally more closely related to one another than to the other groups, with some possible additional differentiation between cutthroat trout from the Clackamas River basin and the southern portion of the Willamette River above Willamette Falls, beginning roughly in the North Santiam River basin and upstream (Johnson et al. 1999).

It is believed that the freshwater form of coastal cutthroat trout above Willamette Falls is not likely to contribute substantially to the abundance of the anadromous form in the lower Willamette River basin. Reasons include the observation that few downstream-migrating coastal cutthroat trout have been counted at the Willamette Falls bypass facility, and the presence of *Ceratomyxa shasta* in the lower Willamette River below the confluence of the Marys River. Because of their susceptibility to this parasite, the downstream migration of freshwater coastal cutthroat trout is thought to be effectively blocked (Johnson et al. 1999).

4.1.8.2 Population Trends

Nehlsen et al. (1991) considered coastal cutthroat trout in the lower Columbia River streams below Bonneville Dam to be at moderate risk of extinction. Nickelson et al. (1992) evaluated the status of coastal populations of coastal cutthroat trout in Oregon. They stated that most coastal populations of coastal cutthroat trout in Oregon were of unknown status due to insufficient data. Anecdotal information, results from creel surveys, and fish counts at dams indicated that anadromous cutthroat trout populations may be experiencing widespread decline. Kostow (1995) described the abundance of anadromous cutthroat trout in the lower Columbia River basin as having declined significantly in 1994, where anadromous cutthroat trout presently occur only in the lower Willamette River below Willamette Falls. Occurrences in the Clackamas River were much less abundant than in the past, although freshwater forms of coastal cutthroat trout were described as abundant and well distributed throughout headwater and lower Clackamas River tributaries (Kostow 1995; Johnson et al. 1999).

Hooton (1997) also reviewed abundance and trend information for all life-history forms of coastal cutthroat trout. Non-migratory coastal cutthroat trout were reported to be widespread and dominant in most headwater tributaries; however, population sizes were described as likely to be lower in abundance than in the past due to habitat degradation and loss. River- and lake-migrating forms of coastal cutthroat trout were reported to have mixed status: some populations were considered healthy, but for many, information was insufficient to determine population health. Anadromous cutthroat trout in Oregon were likely to have suffered significant declines in the past decade, and population trends are presently downwards in many streams of this ESU with decline rate estimates generally ranging from 5 to 11 percent per year (Johnson et al. 1999).

4.1.8.2.1 Population and Catch Sizes

The number of anadromous adult cutthroat trout in lower Columbia River streams is almost universally very low. The anadromous cutthroat trout runs in the Hood and Sandy rivers are considered to be severely depressed. There have been no verified observations of anadromous cutthroat trout on the Sandy River in recent years. There is little information about the distribution of freshwater forms of coastal cutthroat trout in this ESU, and almost no information about relative abundances of migratory and nonmigratory freshwater forms (Johnson et al. 1999).

Trends in incidental catch of coastal cutthroat trout in steelhead and salmon recreational fisheries in the lower Columbia River are similar to long-term trends estimated from escapement to streams. The recreational catch of coastal cutthroat trout in the lower Columbia River was

approximately 5,000 fish per year in the 1970s; by the late 1980s, the catch had declined to approximately 500 per year. These catch data are subject to some uncertainty because of unknown variability in fishing effort (Kostow 1995; Johnson et al. 1999).

Cutthroat trout are among the salmonids most vulnerable to overharvest by angling, especially during postspawning outmigrations to summer feeding areas. This relatively heavy harvest mortality on repeat spawners has been a concern of biologists in the Pacific Northwest for many years, especially as first-year coastal cutthroat spawners often have fewer and poorer quality eggs than do repeat spawners. Hatchery coastal cutthroat trout fisheries are still fairly active in the lower Columbia River basin. Catch and release regulations recently were imposed in the lower Columbia River and in portions of the Willamette and Sandy rivers. More restrictive bag and size limits have been imposed in recent years for other Oregon and Washington streams (Johnson et al. 1999).

4.1.8.2.2 Hatchery Contribution To Natural Production

Artificial propagation has generally attempted to provide fish for recreational harvest in the lower Columbia River. The ratio of hatchery to naturally produced coastal cutthroat trout on the West Coast varies from region to region and from watershed to watershed within a particular ESU, with coastal cutthroat trout populations dominated by hatchery production in some areas and maintained by natural production in others. Even small but persistent contributions from hatchery fish can affect the genetic makeup of local populations. In most cases, hatchery programs for coastal cutthroat trout have been small and of short duration compared to programs for other anadromous salmonids. The programs have not produced substantial numbers of coastal cutthroat trout relative to natural production, although estimates of the percentage of hatchery coastal cutthroat trout in lower Columbia River sport catch ranged from 50-80 percent between 1979 and 1982 (Johnson et al. 1999).

Until recently, the transfer of hatchery stocks of coastal cutthroat trout between distant watersheds and facilities was a common management practice in lower Columbia River and southwestern Washington watersheds. Concern about genetic and ecological consequences prompted management agencies to institute policies to reduce the exchange of coastal cutthroat trout stocks among watersheds, primarily by terminating releases of fish in all but a few locations. The effects of long-term hatchery releases of coastal cutthroat trout on natural production in lower Columbia River tributaries in Oregon is unknown (Kostow 1995; Johnson et al. 1999).

4.1.8.2.3 Current Hatchery Fish Releases

Currently, the largest component of hatchery efforts for coastal cutthroat trout in Washington occurs in the lower Columbia River with about 200,000 fish released annually, mostly from the Cowlitz Hatchery. Approximately 75percent of the total effort in Washington is dedicated to this area. In 1997, coastal cutthroat trout were released into the Abernathy and Beaver creeks and the Coweeman, Cowlitz, and Lewis rivers. In addition to state hatchery programs, a cooperative project between Clark Public Utilities, Vancouver/Clark Parks and Recreation, WDFW, and Trout Unlimited is now in its fifth year of releasing fish from net pens in a pond adjacent to Salmon Creek. About 10,000 coastal cutthroat trout from the Skamania Hatchery are released from this facility each year (Johnson et al. 1999).

In Oregon, the planting of hatchery coastal cutthroat trout was discontinued in lower Columbia River streams by 1994. Currently, only standing bodies of water such as lakes and ponds in the lower Columbia River area are planted with hatchery fish. The only current planting of hatchery coastal cutthroat trout in the Willamette River basin occurs in Cascade Mountain lakes, using a native brood stock of coastal cutthroat trout known as the Hackleman stock. The effects, if any, of these introductions on naturally spawning stocks are unknown but are currently under investigation by ODFW (Kostow 1995; Hooton 1997; Johnson et al. 1999).

4.1.8.3 Life History

Coastal cutthroat trout have a complex life history, including fish that do not migrate, those that migrate strictly within freshwater, and those that exhibit anadromy. Coastal cutthroat trout populations may contain both migratory and nonmigratory individuals within the same population. Although all coastal cutthroat trout populations with access to the sea are believed to have an anadromous component, not all members migrate to the sea. Most cutthroat trout that do enter seawater do so as 2- or 3-year-olds, but some remain in fresh water for up to 5 years before entering the sea. Other coastal cutthroat trout never outmigrate at all, but remain in small headwater tributaries. Still others migrate only into rivers or lakes even when they have seawater access. Multiple life-history forms frequently coexist within the same watershed and even the same stream. Degree of anadromy may differ among populations within a basin even when no geologic barrier exists. The diversity in life history exhibited may reflect an adaptive strategy allowing coastal cutthroat trout to exploit habitats not fully utilized by other salmonids (Johnson et al. 1999).

The proportion of coastal cutthroat trout within a basin that exhibit a nonmigratory life history is difficult to determine. Freshwater-migratory populations are best documented in rivers and lakes with physical barriers to anadromous fish, such as above Willamette Falls, where schools of coastal cutthroat trout were found to migrate from natal spawning areas to mainstem feeding areas and back. The anadromous form is the most common life history strategy for this ESU (Johnson et al. 1999).

4.1.8.3.1 Spawning

Return migrations of coastal cutthroat trout in the Columbia system usually begin as early as late June and continue through October, with peaks in late September and October. Anadromous cutthroat trout spawning typically starts in December and continues through June, with peak spawning in February. Spawning occurs predominantly in streams with low stream gradient and low flows, usually less than 0.3 m^3/s during the summer, usually upstream of coho salmon and steelhead spawning zones although some overlap may occur. It is believed that this strategy evolved to reduce competition for suitable spawning sites, hybridization between coastal cutthroat and rainbow trout, and reduce competitive interactions between young-of-the-year coastal cutthroat trout and other salmonids. Cutthroat trout are repeat spawners. Some fish have been documented to spawn each year for at least 5 years, although some do not spawn every year and some do not return to seawater after spawning but instead remain in fresh water for at least a year (Johnson et al. 1999).

4.1.8.3.2 Incubation

Eggs begin to hatch within 6 to 7 weeks of spawning, depending on temperature; alevins emerge as fry between March and June, with peak emergence in mid-April (Johnson et al. 1999).

4.1.8.3.3 Juvenile Rearing and Outmigration

At emergence, fry quickly migrate to channel margins and backwaters, where they remain throughout the summer. Coastal cutthroat trout are found in streams with channel gradients that vary from low (< 2%) to moderate (2-3%) to steep (> 4%), with narrow widths (0.7-3.0 m), and often in small watersheds with drainage areas under 13 km^2 (Johnson et al. 1999).

Coastal cutthroat trout parr generally remain in upper tributaries until they are 1 year of age, when they may begin moving more extensively throughout the river system. Once these movements begin, it is difficult to determine whether fish caught in upstream or downstream traps are parr making a freshwater migration, or smolts on a seawater-directed migration.

Downstream movement may begin with the first spring rains, usually in mid-April with peak movement in mid-May. Some juveniles may enter the estuary and remain there over the summer without smolting or migrating to the open ocean. Upstream movement of juveniles with parr marks from estuaries and mainstems to tributaries appears to begin with the onset of winter freshets during November and continues through the spring, frequently peaking during late winter and early spring. Many of these yearling fish may average less than 200 mm in length and can be found in streams that run through ponds or sloughs (Johnson et al. 1999).

Coastal cutthroat trout that enter the sea generally do so after 2-4 years in the freshwater environment. Time of initial seawater entry of smolts bound for the ocean generally begins as early as March, peaks in mid-May, and is essentially over by mid-June. Seaward migration of Columbia River smolts may occur to more protected areas at an earlier age and smaller size than migration to more exposed areas such as the outer Washington coast. The smolts make their first migration at age 2, at a mean size of about 160 mm (Johnson et al. 1999).

4.1.8.3.4 Ocean Stage

Coastal cutthroat trout that enter nearshore waters reportedly move moderate distances along the shoreline but do not cross large bodies of open water. A fish released near Cape Disappointment was recovered in the Umpqua River, 290 km to the south; another fish released off Yaquina Head was recovered 43 days later in the Siuslaw River, 72 km to the south. Sea-run cutthroat trout along the Oregon coast may swim and/or be transported with the prevailing currents long distances during the summer. It is not clear how far offshore coastal cutthroat trout migrate. Cutthroat trout have been routinely caught up to 6 km off the mouth of the Nestucca River. Coastal cutthroat trout have also been captured between 10 and 46 km offshore; it is unclear whether they were carried by the freshwater plume of the Columbia River or if they moved offshore in search of prey (Johnson et al. 1999).

4.1.8.3.5 Age At Maturity

In general, coastal cutthroat trout exhibit considerable variation in age and size at maturity. Nonmigratory coastal cutthroat trout typically mature when 2 or 3 years old, whereas sea-run cutthroat rarely spawn before age 4 (Johnson et al. 1999).

4.1.8.4 Existing Recovery Efforts

A number of activities have reduced habitat quantity and quality in the lower Columbia River basin. Water development projects on the Willamette and Sandy rivers and in smaller creeks in the lower Columbia River basin have resulted in numerous barriers that are impassable by anadromous salmonids, reducing the amount of available habitat. Habitat impacts due to logging activities probably have led to declines in coastal cutthroat trout population productivity in lower Columbia River tributaries downstream of the Willamette River (Kostow 1995; Johnson et al. 1999).

NMFS concluded that the southwestern Washington/Columbia River ESU was likely to become endangered in the foreseeable future, based on concerns over widespread declines in abundance and small population sizes of anadromous cutthroat trout found throughout the lower Columbia River, as exemplified by near-extinction of anadromous cutthroat trout runs in the Hood and Sandy rivers. The severe reductions in abundance of this life-history form could have deleterious effects on the ability of this ESU to recover from widespread declines. Reductions in the quantity and quality of nearshore ocean, estuarine, and riverine habitat, and recent increases in marine mammal and bird predators have probably contributed to declines, but the relative importance of these risk factors is not well understood (Johnson et al. 1999).

Steps have been taken recently by the states of Washington and Oregon to reduce mortality due to directed and incidental harvest of coastal cutthroat trout (Johnson et al. 1999).

4.1.9 Upper Willamette River Cutthroat Trout DPS

As for the coastal form, much of the available information for upper Willamette cutthroat trout is qualitative or descriptive, rather than quantitative. With the exception of anadromy, there are many similarities between the two ESUs. This section includes information specific to non-anadromous cutthroat trout above Willamette Falls; the reader is referred to the previous section for additional information.

4.1.9.1 Subpopulations and Distributions

Cutthroat are present in all subbasins of the Willamette River above Willamette Falls, including the Long Tom River (Nicholas 1978). The upper Willamette River has probably never supported a substantial anadromous population of cutthroat trout; the primary life-history form above Willamette Falls appears to be freshwater migratory, a type that seems relatively rare below the

falls. Although the populations above the falls are highly heterogeneous genetically, they do form a somewhat coherent cluster of apparently isolated and semi-isolated populations (Johnson et al. 1999).

4.1.9.2 Population Trends

Nicholas (1978) found reports of good sport fishing for cutthroat in the mainstem Willamette River above Independence in the 1920s and 1930s, but the fishery was later eliminated by pollution. The population of cutthroat rearing in the Willamette River above Corvallis has rebuilt since the 1960s after pollution was curtailed. Cutthroat are the only native trout on west side tributaries of the Willamette River, and on the east side tributaries they tend to be more abundant than rainbow only in the upper portions of the basins.

4.1.9.2.1 Population and Catch Sizes

Counts are available for cutthroat trout in a few tributaries in the Willamette River basin. Uniquely large populations of the river-migrating form occur in the mainstem areas of the Willamette River and its tributaries. Increasing numbers of cutthroat trout have been documented by seining in three sites in the mainstem Willamette River between Corvallis and the mouth of the McKenzie River (RKm 132-175) from 1992-1998. The numbers of coastal cutthroat trout longer than 60 mm caught per seine set ranged from 0.2 to 8 fish. Over the 7 years of sampling, the numbers of fish caught increased by 11 percent to 83 percent per year, depending on the location. Some of this increase is due to increase in sampling efficiency. In addition, population indices for cutthroat trout in the lower McKenzie River were estimated using electrofishing from 1988-1993. The estimated number of river-migrating cutthroat trout per mile of shoreline ranged from 113 to 333 fish per mile for fish greater than 20 cm. Combined counts of cutthroat trout and rainbow trout (15-31 cm) in index pools in the North Fork of the Middle Fork Willamette River increased between 1975 and 1991, and the counts have remained stable since then. The abundance of juvenile cutthroat trout (age-1 and -2+) in an index reach of Dead Horse Canyon Creek, a tributary of the Molalla River was stable from 1981-1991. Scattered sampling of cutthroat trout in the Santiam and McKenzie river basins in the late 1970s to early 1980s indicated that densities of all age classes combined ranged from 61 to 2,200 fish per km. Numbers of cutthroat trout in streams of the Coast Range subbasin of the Willamette River ranged from 166 fish/mile in the North Yamhill River, to more than 1,700 fish/mile in the Little Luckiamute River basin (Hooton 1997; Johnson et al. 1999).

4.1.9.2.2 Hatchery Contribution To Natural Production

Historically, tributaries of the Willamette River above Willamette Falls received hatchery coastal cutthroat trout from a variety of sources. Coast Range tributaries tended to get plants of anadromous stocks (mostly Alsea Hatchery fish), while Cascade Range tributaries tended to receive the Leaburg stock, which appears to have been derived from a local Willamette River freshwater strain native to the Long Tom River. Most of the hatchery effort in Willamette River tributaries occurred in the 1950s and 1960s (Johnson et al. 1999).

4.1.9.2.3 Current Hatchery Fish Releases

The only current planting of hatchery coastal cutthroat trout in the Willamette River basin occurs in Cascade Mountain lakes, using a native brood stock of coastal cutthroat trout known as the Hackleman stock (Johnson et al. 1999).

4.1.9.3 Life History

Not all cutthroat trout in the Willamette River basin exhibit migratory strategies. For example, most (97%) cutthroat trout in Lookout Creek, a small tributary of the Willamette River appear to exhibit a nonmigratory strategy (Wyatt 1959). Other tributaries contain populations that undergo relatively extensive migrations between the mainstem Willamette and tributaries, and not all migrating fish are necessarily mature (Nicholas 1978).

4.1.9.3.1 Spawning

Spawning occurs primarily if not exclusively in small tributaries. The spawning period is protracted from January through July, with spawning earlier in tributaries on the valley floor than at higher elevations of the Cascade slopes. Timing patterns in the basin appear to be related to water temperatures and runoff patterns (Nicholas 1978).

4.1.9.3.2 Juvenile Rearing and Migration

There is evidence of fry movement downstream to larger streams from June through November, with the bulk occurring closer to June than to November (Wyatt 1959).

4.1.9.3.3 Fluvial/Reservoir Stage

Cutthroat trout above Willamette Falls exhibit resident and fluvial life histories, but not anadromy because upstream passage is apparently prevented by Willamette Falls. Some cutthroat trout appear to move upstream from larger streams into small tributaries from late fall through early summer, but not all migrating fish are maturing (Nicholas 1978). The fluvial life history is common in the Willamette system (Sumner 1972).

Wyatt (1959) captured adult cutthroat trout moving in and out of small tributaries of the McKenzie and Middle Fork Willamette river subbasins from November through June, although movements ceased when water temperatures fell below 3.3°C. Others have observed cutthroat trout moving upstream in November (Nicholas 1978).

Nicholas (1978) cited several examples of scale collections from Willamette River basin cutthroat that indicated the fish had grown more rapidly in their third or fourth year of life. He interpreted this change in growth as the result of migration downstream to a larger stream or the main stem Willamette River. Nicholas reported finding a similar pattern indicating "migration of cutthroat trout from small nursery tributaries into larger streams, "from scales of cutthroat collected in the McKenzie, Santiam, and Willamette rivers."

4.1.9.3.4 Age At Maturity

Adult cutthroat trout in higher elevation tributaries are generally smaller in size at maturity than trout found in lower elevation tributaries and the mainstem Willamette River. Maturity occurs at either age 2 or age 3 (Nicholas 1978).

4.1.10 Oregon Chub

Oregon chub live in quiet water areas such as backwaters and sloughs, and are endemic to the Willamette River basin. A more complete description of their habitat requirements and life history is given in USFWS (1998). Pertinent information is summarized here.

4.1.10.1 Distributions and Population Size

Oregon chub were found historically throughout the Willamette River basin between Oregon City and Oakridge, in the Clackamas, Molalla, South Santiam, North Santiam, Luckiamute, Long Tom, McKenzie, Mary's, Coast Fork Willamette, Middle Fork Willamette, and mainstem

Willamette rivers. There are currently 20 naturally occurring populations found in the Santiam, Middle Fork Willamette, and Coast Fork Willamette rivers, and in several smaller tributaries to the mainstem Willamette River. Only 7 of these 20 populations have numbers exceeding 1,000 fish, and twelve have populations comprised of less than 100 individuals. Four other populations have been reintroduced recently, two to a slough and pond along the Middle Fork Willamette, one to a pond located on a tributary to the Middle Fork, and one in the Fall Creek dam spillway reach. Within the entire Willamette River basin, Oregon chub numbers total about 28,000 fish circa 1998 (USFWS 1998a).

Oregon chub are not separated into distinct population segments and no genetic data have been collected to indicate the existence of different segments. Mixing was more likely for downstream than upstream populations (USFWS 1998a).

Abundance of Oregon chub appears to be related presently to the degree of connectivity of habitat to the river (Scheerer 1999). Isolated habitats appear to contain the greatest densities of chub. Habitats that are more frequently and directly connected appear to be more accessible to competing and predatory non-native fish species, and there is an inverse relation between non-native species' and Oregon chub population size.

4.1.10.2 Population Trends

Population trends of Oregon chub vary, but there are some broad patterns suggested in USFWS (1998). The following apparent trends are noted for populations potentially influenced by Willamette Project activities:

- Populations in the Santiam system are either stable, declining, or recently extirpated in some cases (Scheerer et al. 1998);

- Populations in the Middle Fork Willamette River between the Coast Fork Willamette River and Fall Creek are declining (possibly extirpated -- Scheerer et al. 1998);

- Populations in the Middle Fork Willamette River between Fall Creek and Dexter Dam, and in alcoves of Dexter Reservoir, are increasing;

- Populations in the Middle Fork Willamette River upstream of Lookout Point Reservoir are stable or increasing.

The largest populations of Oregon chub are found in the Middle Fork Willamette River basin; all populations in the Santiam basin except one are small in size.

4.1.10.3 Life History

Relatively little is known about Oregon chub life history. Research is currently underway to change this situation (e.g., Sheerer et al. 1998).

4.1.10.3.1 Spawning and Incubation

Oregon chub typically spawn from April through August when water temperature is between 16EC and 21EC. Eggs are adhesive and are generally attached to vegetation. There are no known spawning migrations. Hatching appears to occur within three to ten days after spawning (Scheerer et al. 1998).

4.1.10.3.2 Rearing and Migration

Juveniles and adults live within the same areas where spawning occurs and may not migrate to new habitats voluntarily, which may partially explain why Oregon chub tend to be found in isolated pockets and do not readily recolonize unexploited areas. It is possible that redistribution may have occurred historically during flooding.

4.1.10.3.3 Age at Maturity

Oregon chub generally live to six years in age, with the majority of fish 4 years old and younger. Maturity may occur when the fish is about two years old (Scheerer et al. 1998).

4.1.10.4 Existing Recovery Efforts

The decline of Oregon chub has occurred for a number of reasons. The most important include habitat alteration and loss (through side channel elimination, increased sedimentation of quiet water habitat, and reduced water quality), the introduction and spread of non-native fish and amphibious species that prey on or compete with chub, and population fragmentation through the construction of dams and influences on habitat distributions. These factors continue to influence the recovery potential for this species (USFWS 1998a).

Previous consultation with the USACE indicated that the Dexter/Lookout Point, Fall Creek, and Hills Creek projects had the highest potential to influence Oregon chub populations. The Foster/Green Peter, Big Cliff/Detroit reservoirs were determined to have a moderate influence.

Additional conservation measures were implemented including reintroduction of populations to other locations. The USACE is also funding studies into the biology and ecology of Oregon chub per requirements of the consultation (USFWS 1998a).

Present recovery efforts focus on reintroduction of populations to new locations, control of non-native species populations, and habitat enhancement work creating new pond and quiet water habitat and wetland restoration. Monitoring is an important part of the recovery plan (USFWS 1998a; Scheerer et al. 1998). Most recently, Oregon chub were reintroduced to a perched beaver pond near Foster Reservoir in 1999, as part of recovery efforts in the Santiam subbasin under the Oregon Chub Recovery Plan (P. Scheerer, personal communication, February 2000).

4.2 WILDLIFE

4.2.1 Gray Wolf

Gray wolves (*Canis lupus*) are highly social canids that live in packs of two to eight or more individuals. Territories may range from 50 to as much as 1,000 square miles depending on prey availability and movements. Individuals dispersing from packs may travel as much as 500 miles. Pack leaders are typically the only individuals within packs that breed, with the young usually born in April or May. The pack cooperates both in rearing the young, and in hunting. Prey may include deer, elk, bighorn, mountain goats, as well as on ground squirrels, rabbits, and hares. Prior to European settlement, gray wolves were abundant and widespread. They occupied all habitats where large mammals were found. The species was once the most abundant, widespread large predator in North America.

4.2.2 Columbian White-tailed Deer

The Columbian white-tailed deer (*Odocoileus virginianus leucurus*) is a subspecies formerly common in bottomland and prairie woodland habitats throughout the Columbia, Willamette, and Umpqua Basins. Ranging from 85 to 150 lbs, (39 to 68 kg), this subspecies of white-tailed deer has characteristic white rings around the eyes and just behind the nose. In Douglas County, this subspecies is found associated with dry rolling hills, grasslands, and oak forests, but riparian areas along major rivers are the preferred habitat for this threatened species. Its decline was attributed to the conversion and loss of habitat for agriculture and urbanization, as well as to uncontrolled hunting. By the early 1900s, the species was extirpated over most of its range, with remnant herds in the Lower Columbia River and an isolated population in Douglas County. In the 1930s, the population in Douglas County was only 200 to 300 individual deer in an area of approximately 30 square miles. Today, the population is estimated to be 5,500 deer ranging

within an area of 308 square miles. The densest population of Columbian white-tailed deer in Douglas County is within 0.6 mile of the North Umpqua River. The increase in numbers is attributed to a prohibition of hunting and a protection of habitat. The BLM manages 6,581 acres exclusively for the management of this species. The Douglas County population of the Columbian white-tailed deer was proposed for delisting on 11 May 1999. A decision is anticipated by 11 May 2000.

4.2.3 Marbled Murrelet

The marbled murrelet (*Brachyramphus marmoratus*) is a small, robin-sized diving seabird that nests along the coast of the Pacific Ocean. The species feeds mainly on small fish and invertebrates and breeds inland. It nests on large limbs of mature conifer trees in low-elevation, older forests, typically within 50 miles (80 kilometers) of the shore. The nest is typically a small depression or cup in moss or other debris. Nesting may occur between late March and late September, with incubation and fledging occurring over 30 and 28 days, respectively. Young are fed on fish that are carried individually from the ocean by the adults. The decline of marbled murrelets has been attributed to high rate of habitat loss and fragmentation, as well as mortality associated with net fisheries and oil spills.

4.2.4 Aleutian Canada Goose

The Aleutian Canada goose (*Branta canadensis leucopareia*) is a small (3-4 lbs) subspecies of Canada goose that is distinguished by a grayish-brown breast and a broad, white neck ring that completely encircles the lower neck. This species nests on a few islands within the Alaska Maritime National Wildlife Refuge in the Aleutian Islands of Alaska. This subspecies winters primarily in California, but the Oregon and Washington coasts are used by small populations in winter and during migration. Important wintering areas in Oregon include the New River area near Langlois, and the Oregon Islands National Wildlife Refuge near Pacific City. The Aleutian Canada goose is rarely seen far from coastal areas, but may occasionally occur in the Willamette Valley. Prior to December 1990, this subspecies was listed as endangered.

The introduction of foxes for the fur trade industry to many Aleutian Islands, including those used for nesting by the Aleutian Canada goose, is considered the primary reason for the decline of this subspecies. Predation by Arctic foxes (*Alopex lagopus*) and red foxes (*Vulpes vulpes*) on nesting Aleutian Canada geese lead to a sharp decline. Other attributed factors include hunting on migration and wintering habitats, and loss and modification of habitats within the subspecies' wintering and migration range. On 3 August 1999, the Aleutian Canada goose was proposed for

removal from the list of threatened and endangered species. Factors attributed to the recovery are the removal of introduced foxes from some of its nesting islands, the establishment of new breeding colonies, and protection from hunting, and protection and management of migration and wintering habitat.

4.2.5 Bald Eagle

Bald eagles (*Haliaeetus leucocephalus*) breed throughout the Pacific Northwest and winter from the Alaska panhandle southward. In 1999, there were 343 known occupied breeding territories in Oregon and the Washington portion of the Columbia River Recovery Zone (Isaacs and Anthony 1999). Some bald eagles are year-round residents near their breeding territories, but others, typically those found further north where waters often freeze, migrate in winter. They are most abundant during the winter when there is an influx of birds from the north, but there are substantial spring and summer nesting populations.

Bald eagles feed primarily on fish, small mammals, waterfowl, and carrion (Ehrlich et al. 1988). They typically forage from perches or while soaring (Stokes and Stokes 1989; Ehrlich et al. 1988). In general, bald eagle foraging activity is concentrated around one or two periods of time. Feeding activity most often occurs between sunrise and 10:00 am, the peak occurring between 5:00 and 6:00 am. A second period of foraging may occur just prior to sunset (Garrett et al. 1988).

Bald eagles prefer to nest in areas that are primarily mature or old-growth timber near in close proximity to water and available fish sources. Territory shape and size varies with terrain, vegetation, and food availability. Nesting pairs typically forage over an area between 1.0 and 1.25 miles. They generally use the same nest site year after year, though often alternative nest sites are also established and maintained, and are used in the case of damage to the preferred nest site. In Oregon, bald eagles typically begin exhibiting courtship and nesting behaviors in January with egg laying and incubation occurring in February and March. Young are reared throughout April, May and June, and fledging occurs in July and August (Isaacs et al. 1983). Usually only one of the two or three hatchlings survives to leave the nest. Juveniles take about four years to develop adult plumage and reach sexual maturity.

Bald eagles winter along ice-free lakes, streams, and rivers. If sufficient winter food sources are available, a nesting pair may remain in proximity to the nest site throughout the winter (Swenson et al. 1986). Most eagles that breed in Oregon and Washington winter in the vicinity of their nests (Garrett et al. 1988). Wintering bald eagles concentrate in areas where food is abundant and disturbance is minimal and use perches that are selected for their proximity to a food source

(Washington Department of Wildlife 1991). They congregate near sources of food, generally rivers, lakes and the marine shoreline. Wintering bald eagles depend on suitable roosts in sheltered timber stands at night and during severe weather. Winter roosts may be as much as 32 kilometers (20 miles) from foraging areas, and are often in stands of mature or old-growth conifers, but can also be in large deciduous trees on basin floors (Marshall et al. 1996).

4.2.6 Northern Spotted Owl

Habitats selected by northern spotted owls (*Strix occidentalis*) typically exhibit moderate to high canopy closure (60 to 80 percent closure); a multi-layered, multi-species canopy dominated by large overstory trees; a high incidence of large trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and debris accumulations); large accumulations of fallen trees and other debris; and sufficient open space below the canopy for owls to fly (Thomas et al. 1990). These attributes are usually found in old growth, but they are sometimes found in younger forests, especially those that contain remnant large trees or patches of large trees from earlier stands. Dispersal habitat includes stands that have at least an 11 inch average tree diameter and at least 40 percent canopy closure (Thomas et al. 1990).

Spotted owl pairs occupy the same territories year after year as long as suitable habitat is present. However, nesting may not occur every year, and survival of offspring varies annually and geographically. Nest trees are often used more than one year, but occasionally a pair will switch to a new nest tree within their home range. Spotted owls begin their annual breeding cycle in late winter (late-February to early-March) when the pair begins to roost together (Thomas et al. 1990). One to three eggs, usually two, are laid in March or April. Incubation lasts for approximately 30 days, and juvenile owls leave the nest 3 to 5 weeks after hatching. Many abandon the nest site well before they are able to fly. Both parents feed the young until August or September. The young become independent in September or October, at which they disperse from the parental nest areas.

4.2.7 Fender's Blue Butterfly

Fender's blue butterfly (*Icaricia icarioides fenderi*) is a Willamette Valley endemic subspecies that was considered to be extinct until collected in 1985. This subspecies is known to use Kincaid's lupine as its primary larval food plant. It may however use spurred lupine (*Lupinus laxifloris*) or sickle-keeled lupine (*Lupinus albicaulus*) if Kincaid's is also present. Adults lay their eggs in late May or early June on the foliage of lupine. Larvae emerge to feed on foliage during late June, before crawling to the base of the plants in July and entering diapause. From

this point until the larvae emerge from the base of the plant to begin feeding on foliage again the following April, the larvae will be found at the base of the senescing plant, or in the litter immediately adjacent to the lupine stem.

The density of Fender's blue butterfly has been positively correlated with the number of Kincaid's lupine flowering racemes, and more recently to nectar production in native plants used for nectaring by adult Fender's blue butterflies (Schultz and Dlugosch 1997). Fender's blue butterfly uses several native flower species as nectar sources, and presence of exotic grasses, including tall oatgrass, can effectively preclude butterflies from using a patch of Kincaid's lupine (Hammond 1994). Oatgrass can also out-compete native forb nectar sources, including *Allum amplectens*, *Camassia quamash*, *Eriophyllum lanatum*, and *Sidalcea virgata*.

Historically, extirpation of small local populations of Fender's blue butterfly was probably common but may have typically been followed by recolonization from neighboring sites over time. Today, remnant upland prairie acreage is extremely fragmented and remaining populations of Fender's blue butterfly so small, that this process is not expected to function to maintain the population over time. Extinction of remaining small populations is expected from localized events, including impacts of low genetic diversity occurring in very small populations (63 FR 3863).

4.2.8 Canada Lynx

Canada lynx (*Lynx canadensis*) habitat in the Cascade Mountains consists of coniferous forests of mixed age and structural classes. Early successional forest stages provide habitat for the lynx's primary winter prey, the snowshoe hare. Mature forests with downed logs and windfalls provide cover for denning sites, escape, and protection from severe weather. A key component of lynx habitat is dense understory vegetation. The species makes extensive use of riparian vegetation, particularly areas with dense, shrubby willow and alder stands.

Lynx breed in late winter and, after a gestation period of at least 60-days, one to four young are born, usually in March or April (Ingles 1965). Young are weaned in about 2 months. The home range of a lynx can be up to 100 square miles. They are capable of moving extremely long distances in search of food. In the Cascade Mountains, Canada lynx exhibit seasonal elevation movements (Lee, personal communication, 1999), possibly in response to prey availability. The species occupies lower elevations (below 5,000 feet) in winter, particularly during periods of heavy snow cover. In spring, as the snow melts, lynx move to higher elevations.

4.3 PLANTS

4.3.1 Golden Paintbrush

Golden paintbrush (*Castilleja levisecta*) is a regional endemic plant of the snapdragon family (Scrophulariaceae) that occurs in meadows and prairies at low elevations from Vancouver Island, British Columbia throughout the Puget Trough and Willamette Valley (Hitchcock and Cronquist 1973). This species flowers from April through August. It is a multi-stemmed perennial that has bright yellow bracts. It is the only yellow-bracted paintbrush in its range. The species was listed as threatened by USFWS on 11 June 1997; no critical habitat was designated for the species. Possible contributions to the decline of this species include loss of habitat due to housing development, grazing, agriculture, and park maintenance (WNHP 1981).

4.3.2 Howellia

Water howellia (*Howellia aquatilis*) is an annual aquatic plant in the bellflower family (Campanulaceae) that is regionally endemic, and was listed as threatened on 14 July 1994 (59 FR 35864). No critical habitat has been designated for the species. It was first discovered and originally described from a location on Sauvie Island in Oregon, and was also documented at three other sites in Oregon (Clackamas, Marion and Multnomah Counties) where it occurred within the floodplains of the lower Columbia and Willamette Rivers (59 FR 35864, Shelly and Moseley 1988). It is now, however, believed extirpated in this state (59 FR 35864, 58 FR 19795, Lesica et al. 1988, ONHP 1998, Vrilakas, personal communication, 2000). Recently, it is documented in three widely separated areas in Washington, Idaho and Montana, one of these locations is on Ridgefield National Wildlife Refuge along the Columbia River (Gamon 1992; Lesica et al. 1988), just upstream of the mouth of the Lewis River.

Water howellia occurs in low-elevation sloughs, ponds, and other marshy areas that are seasonally inundated but are dry or nearly dry late in the growing season; it is not found in sites that are submerged throughout the entire year (Lesica et al. 1988; WNHP and BLM 1997). The species is found in firm consolidated clay and organic soils (59 FR 35864; 58 FR 19795; WNHP and BLM 1997). It is found in wetlands that are at least partially bordered by broadleaf deciduous trees, in western Oregon and Washington this is Oregon ash (*Fraxinus latifolia*) (USFWS 1996; Gamon, personal communication, 2000). Because the plant is an annual, populations are entirely dependent on yearly recruitment from seed. The seeds require exposure to air to germinate, therefore, germination and survival of seedlings can be highly variable from year to year and result in wide fluctuations in population size (Lesica et al. 1988).

Threats to water howellia include any influences that affect the hydrology (surface or subsurface) of ponds and other wetlands where the species occurs. Additional threats include urbanization, agricultural practices, livestock grazing and trampling, timber harvest, and encroachment by highly invasive reed canarygrass (*Phalaris arundinacea*) and purple loosestrife (*Lythrum salicaria*) (59 FR 35864; 58 FR 19795; Shelly and Moseley 1988). In addition, introduced grass carp (*Ctenopharyngodon idella*) destroy aquatic vegetation and are a further threat to water howellia (59 FR 35864; 58 FR 19795; Shelly and Moseley 1988). The construction of the Columbia and Willamette River dams has been attributed to the decline of suitable pond and other wetland habitats for this species (59 FR 35864; Gamon 1992; Shelly and Moseley 1988).

4.3.3 Bradshaw's Desert Parsley

Bradshaw's desert parsley (*Lomatium bradshawii*) is a plant endemic to western Oregon and Washington. This species was once widespread in wet prairies of the Willamette and Umpqua Valleys. However, much of this habitat has been developed or converted to agricultural lands. This relatively inconspicuous member of the parsley family (Apiaceae) flowers in April and May, with fruit apparent in late May and June. During much of its blooming period, Bradshaw's desert parsley is the only yellow flower in its habitat (Kagan 1980), which aids its detection. After flowering, the plants produce large seeds that are quite noticeable and characteristic of the genus. The species was listed as endangered by USFWS on 30 September 1988; no critical habitat was designated for the species. The seasonally-flooded tufted hairgrass (*Deschampsis caespitosa*) meadow community is the most common habitat for the species, it also occurs rarely in shallow, stream-covered basalt areas (USFWS 1993). Invasion by trees and shrubs, changes in hydrology (flood pattern and movement) critical to seed establishment, as well as urban, agricultural, and rural development are attributed to the decline of Bradshaw's desert parsley.

4.3.4 Nelson's Checker-mallow

Nelson's checker-mallow (*Sidalcea nelsoniana*) is a showy, pink member of the hollyhock family (Malvaceae) and is described as endemic to the Willamette Valley (Hitchcock and Cronquist 1973; Eastman 1990). The species was listed as threatened on 12 February 1993; no critical habitat has been designated for the species (58 FR 8235).

At first thought to be limited in distribution, populations of Nelson's checker-mallow, have been mapped throughout the Willamette Valley (CH2M Hill 1993). It was initially documented that Nelson's checker-mallow inhabits gravelly, well-drained soil (Hitchcock and Cronquist 1973). However, more recent reports indicate that the species occurs in various habitats that range from

open woodlands to grassy meadows and sedge-dominated wetlands characterized by soils that dry out in mid-summer (Glad et al. 1987). It is most often found in grasslands, frequently in areas that are vernally inundated, or at the margins of summer-inundated wetlands (Glad et al. 1987). In addition, this species has been found to tolerate diverse soil types and levels of human disturbance (Glad et al. 1987). Nelson's checker-mallow does not appear to tolerate substrates that are wet throughout the growing season. Grassland populations are recorded along disturbed, rock roadsides in vegetated ditches, and in undisturbed remnants of Willamette Valley prairie habitat. Other populations are located at the edge of sedge dominated wetlands, along riparian corridors, in disturbed areas, and in open woodland. Recorded populations have disappeared following cultivation (Glad et al. 1987; CH2M Hill 1993).

4.3.5 Willamette Daisy

Willamette daisy (*Erigeron decumbens* var. *decumbens*) is a perennial plant in the composite family (Asteraceae). This species is in flower from June into early July. Little is known about this subspecies, but it is believed to be endemic to the Willamette Valley seasonally wet prairies and grasslands. The characteristic community includes tufted hairgrass, California oatgrass (*Danthonia californica*), and rushes (*Juscus* spp). Once a very common plant, the species was nearly extirpated by the 1930s due to conversion of habitat for agriculture and other uses (Eastman 1990). It was rediscovered, however, in 1980. Willamette daisy was listed endangered on 25 January 2000.

4.3.6 Kincaid's Lupine

Kincaid's lupine (*Lupinus sulphureus* var. *kincaidii*) is a perennial forb in the Legume family (Fabaceae). It is one of three varieties of *Lupinus sulphureus* known to occur in Oregon (Eastman 1990). Kincaid's lupine is a native grassland species, usually found associated with native Willamette Valley red-fescue prairie upland habitats. It is in flowers in May and June. It propagates by seed, is pollinated by native solitary bees and flies, and does not effectively self-fertilize.

Kincaid's lupine was historically found in western Oregon valleys as far south as Douglas County. Kincaid's lupine is thought to have colonized areas along the edge of oak woodlands in upland prairies, and to have a much-reduced range in the Willamette Valley resulting from conversion of these habitats by agricultural and other man-made alterations. Recent DNA studies suggest that Kincaid's lupine may have been widespread throughout the valley prior to European settlement (Liston et al. 1995).